POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

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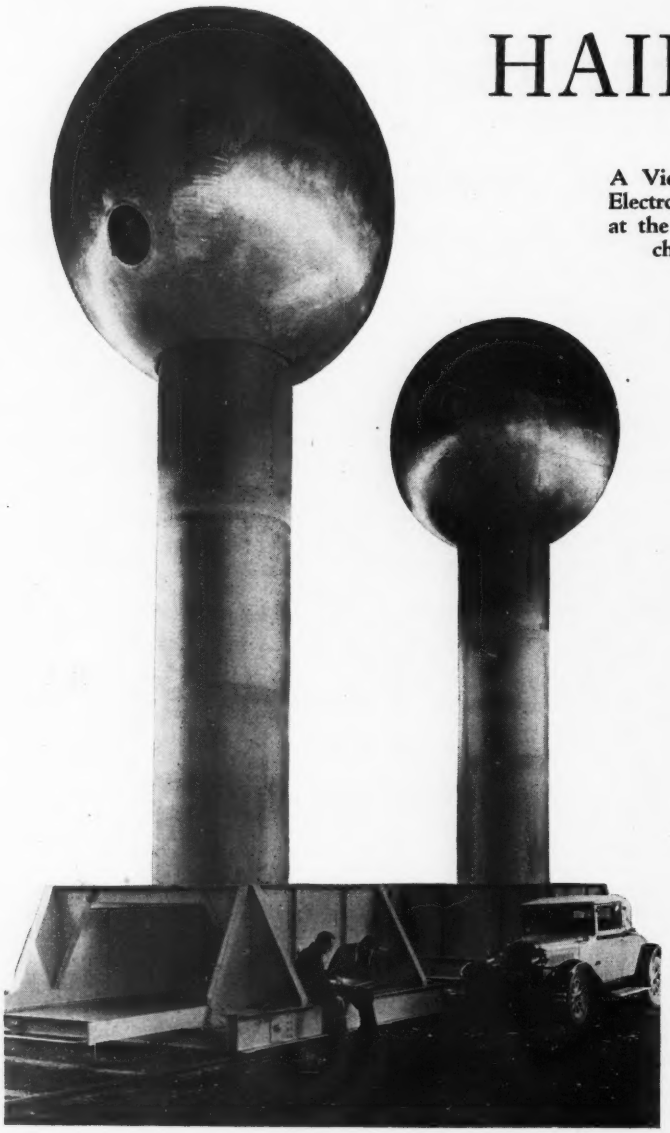
HAIR RAISING



A View of the New Ten Million Volt Electrostatic Generator Being Constructed at the Round Hill Laboratory of Massachusetts Institute of Technology.

WE HAVE READ some hair raising thrillers in our day, we have sat, breathlessly, through terrifying mystery dramas and in our youth at night the local graveyard conspired with our imagination to give us many thrills but never in all our born days have we had a more hair-raising experience than we had when we visited Dr. Robert J. Van de Graaff in his laboratory at the Massachusetts Institute of Technology a few weeks ago. And when we say hair raising we "don't mean maybe;" we mean hair raising, not any mere tickling of the scalp but a real, honest to goodness upward movement of each separate hair. Indeed, we felt a distinct pull right down to the roots.

From this one might gather that Dr. Van de Graaff is another Fu Manchu or Professor Moriarity who tortures and strikes terror into innocent and unsuspecting visitors to his laboratory but such is not the case. Quite the contrary. Dr. Van de Graaff is a most kind and considerate scientist who was only too concerned over our welfare when he explained the mysteries of his ten million volt generator.

"Very well," you say, "but how about your hair—what made that stand on end? What frightened you so much?" Well, the answer to that is we were not frightened at all. Our hair stood on end not because of fear but because of the intense electrostatic field in which we found ourselves when the high voltage generator went into operation. The machine we saw in operation, however, was not the ten million volt generator described on page 216, that was not completed; this was only a small unit of a million and a half volts capacity. So if this small unit made our hair stand on end you can imagine what the large unit at Round Hill will do.

This is only one of the many interesting things going on in the electrical field today. Space does not permit us to describe all of them but we want to mention a few. There is, for instance, the Ignitron Control, described on page 218 developed by Slepian of Westinghouse. Imagine a tiny lead pencil stuck into a pool of mercury exercising absolute and instant control over an electric arc of thousands of amperes. Simple, effective, but puzzling. How does it work? What led to the development of such a device?

It is too long a story to tell here or even in the article on page 218 but it is all part of a study started by Dr. Slepian a number of years ago, into the exact nature of arc formation and ionization. It forms a fascinating story, a mystery drama of the first water and what is more important, one with a happy ending.

Slepian studied circuit interruption; at the General Electric sometime ago they began to devise circuits that did not require interruption—circuits that went off and on with never a break in the conductors—circuits in which there could be no arcs. And here again the story has a happy ending, though it is by no means finished. The non-linear circuit described on page 219 is one result of this study but the principle is broad and no doubt it will have many useful applications. Already it has been applied to the control of a large electric sign.

These are the things that make modern engineering such a fascinating game. Ten years ago none of these things were dreamed of even by far-sighted electrical engineers. Today they are realities—realities which again lead the way into unknown paths and fields still undreamed of.

WITH THE EDITORS

Proper Operating Methods

IN THE FINAL analysis practically all equipment purchased today will give satisfactory service if properly operated and installed. One machine may do this better than another, with less waste, lower power consumption or with greater reliability but, as far as the fundamental operation is concerned, they must all receive proper attention and be properly installed if results are expected.

Unfortunately all pieces of equipment do not receive this attention and are condemned through no fault of their own. Certainly there is no excuse for a company sending out a machine without adequate instructions for installation and operation. Only too often these instructions are of little practical value to the man who has to set the machine up and often they never reach him at all. If they do reach the man who sets up the machine there is little chance of their later reaching the man who operates it. Complicated written instructions are difficult to follow.

Quite commonly manufacturers' representatives are sent to erect complicated equipment and these men should make it a point to instruct the operators, if they are available. Recently, one new power plant went a step farther than this and, in the contracts for equipment, specified that each manufacturer have a competent man instruct the operating crew, these men to stay from four to seven days after the plant started. In this way the regular operating crew was available for instruction and had the advice and assistance of capable help in case of trouble. If extended, this practice would do much to prevent the common and usually groundless statement that "Such-and-such equipment is no good at all." Usually it's the fault of the man, not the machine.

Refrigeration and Our Food Supply

IN NO FIELD has industrial research produced more important results than in that of refrigeration, where the new quick-freezing processes developed are destined to play important parts in organized food distribution.

Flesh foods, when frozen by the usual methods, have the individual cell structure broken down by large ice crystals so that appearance, flavor and food value are affected. This is avoided with quick freezing, where the ice crystals have no chance to grow large enough to break down the cell structure.

Vegetables are not so successfully handled, because the inflexible cellulose walls are frequently ruptured by expansion of the cell contents during freezing and apparently the protein matter coagulates so that it does not reabsorb the moisture content when thawed. For these reasons frozen vegetables seldom have the appearance of the fresh product. Balanced against this is the lessened time required for cooking. Apparently freezing breaks up the cell structure and coagulates the protein much the same as cooking does so that, in many cases, frozen vegetables cook in about half the time of fresh vegetables. Further research will probably make it possible to handle fruits and vegetables as successfully as meat and fish.

The Electron-Volt

INVESTIGATIONS into new, unknown, or untrodden fields of research demand new measuring rods, new units, new degrees of magnitude. Before the days of the ultra-microscope and the spectroscope in the measurement of length, the mile, the foot, the meter, the centimeter and the millimeter were adequate, but when it became necessary to measure light waves and the spacing between atoms in solids, the micron, the millimicron and the Angström unit came into use. So also, when it became necessary to measure sound, the decibel was invented.

Recently there has crept into technical literature concerned with electrical matters, particularly those relating to fundamental investigations of matter and energy as well as X-rays and vacuum tube phenomena, a new unit known as the electron-volt. This unit is not known so well as it should be for it is a particularly appropriate one and paradoxically enough is used to express at once energies inconceivably large and inconceivably small! The electron-volt hardly requires explanation; its name is its definition. It represents the kinetic energy of an electron after falling through a potential of one volt, just as a foot pound represents the energy of a mass of one pound after it has fallen through a distance of one foot. In the production of X-rays, for example, electrons emitted from a cathode are accelerated by the potential between the anode and the cathode. The energy of the electrons striking the anode therefore can be measured in terms of volts, since the energy is proportional to the potential existing across the tube elements. The total energy directed against the anode therefore is expressed in terms of the product of the number of electrons by the potential through which they fall, that is, in electron-volts.

An electron-volt is an inconceivably small unit of energy compared to an erg or a calorie, but it is often used to express the most concentrated energies of which we have any knowledge. In recent measurements of the energies of cosmic rays, corpuscles have been found which have energies of scores and even hundreds of millions of electron-volts! Compared to this, the most intense concentrations of energy that we know of are as nothing. The energy released in the most violent chemical changes such as in formation of hydrogen molecules or water molecules out of their atoms is seldom as much as 10 electron-volts per molecule involved. Even the tremendous energies of the alpha particles emitted by certain radioactive elements are less than ten million electron-volts!

Thus it can be seen that the electron-volt is an extremely fundamental unit of energy and one that is certain to find great application in the ever growing field of electronics. For this reason, if for no other, one should be conversant with it.

POWER PLANT ENGINEERING May 1933

Modernizing a 30 Year

Minneapolis Power Station of the Minneapolis Street Railways Co. Built over 30 years ago, completely modernized by the addition of New High Pressure Boilers and Rebuilding of 20,000-kw. Turbine. ¶ This work involved the solution of many interesting Engineering Problems not usually encountered in the construction of a new Plant.

MODERNIZATION is a phase of power plant work bound to receive increased attention during the next few years. Many plants that are 10, 20 or even 30 yr. old are in good operating condition but in the light of recent technical advances they are obsolete; so expensive to operate that new modern equipment pays for itself in a few years' time.

An excellent example of modernization has just been completed in the Minneapolis Power Station of the Minneapolis Street Railways Co. at Minneapolis, Minn., under the direction of Sargent & Lundy, Inc. of Chicago. The station, started about 30 yr. ago and designed by Sargent & Lundy, consisted of four 5140 sq. ft. and twenty-four 5560 sq. ft. boilers set in batteries and six 200 lb. ga., 550 deg. F., 3500-kw. engine units. In 1906, two 5000-kw. vertical turbines were added and beginning in 1911 the engines were replaced by one 14,000 and two 15,000-kw. vertical turbines. Boiler feedwater taken from the river was filtered but not further treated, while coal and ash were both handled by pivoted bucket conveyors, one serving each side of the boiler aisle as shown at the top of Fig. 2. All auxiliaries were steam driven, the exhaust being used in open feedwater heaters.

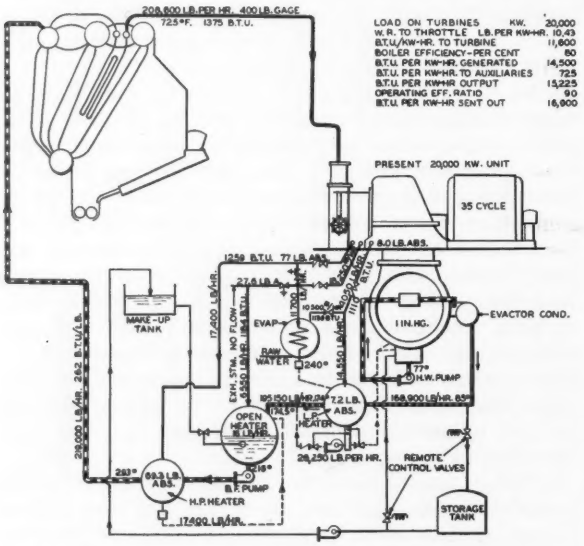


FIG. 1. PERFORMANCE DIAGRAM OF MINNEAPOLIS STATION FOR FULL LOAD

To increase the station capacity, the company in 1916 replaced the last 3500-kw. engine unit with the present No. 4, 20,000-kw. horizontal General Electric turbine. This turbine was rebuilt in 1931 for 400 lb., 725 deg. F. and three stages of extraction provided as part of the modernization plan. Later, eight of the old 5560 sq. ft., 200-lb. boilers were replaced by two 16,438 sq. ft., 460-lb. boilers with economizers and air heaters.

Rebuilding a station in this way differs greatly from building a complete new station and taxes the ingenuity of the engineers. Existing building limitations and present equipment arrangements must be considered with heaters, surge tanks and other items of the modern cycle squeezed in where space permits.

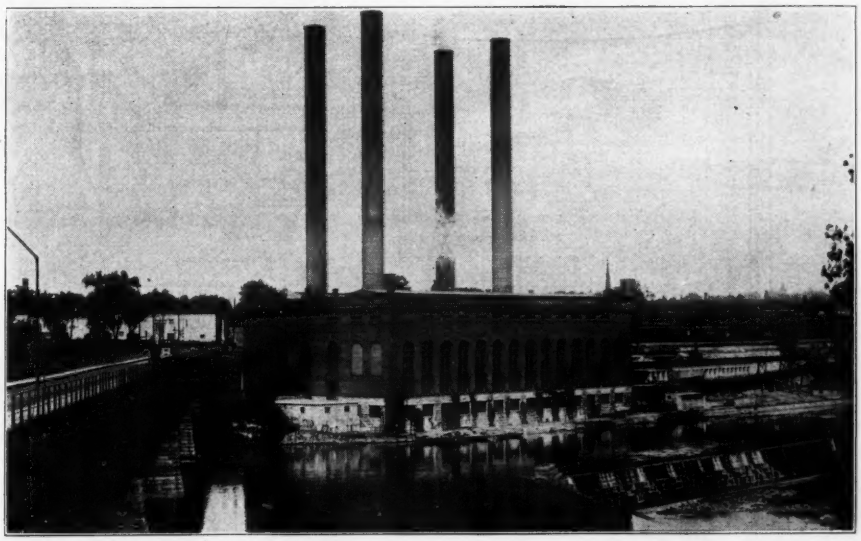
Unusual Problems

For instance, location of the high-pressure steam line was quite a problem inasmuch as the old low-pressure line could not be removed to give the necessary space in the usual location between the boilers and turbines. This line was finally run out and back through the firing aisle of the old boiler room as shown by Fig. 3.

In order that the new boilers may be used with the old equipment a cross-over connection between the 400 and 200-lb. systems was installed and received particular attention. A Schutte & Koerting single seated balanced Venturi valve acts as both a reducing valve and desuperheater. The location of this valve can be seen in the plan, Fig. 3, and the schematic control arrangement in Fig. 4. Both pressure and temperature are controlled by Askania jet pipe regulators, the former being regulated by moving the valve spindle and the latter by controlling the amount of water injected.

Another interesting problem came in connection with the ash disposal system. It was possible to use the existing pivoted bucket conveyors for supplying the coal bunkers but it was not possible to locate the ash pits of the new boilers over the return conveyor. To remedy this the unique arrangement shows by the cross-sectional drawing was used. Each ash pit is fitted with four hand operated gates discharging to 4 by 3 ft. Beaumont reciprocating feeders driven by direct current motors, the four feeders on each boiler being driven through a shaft by one motor. Driving motors are located on opposite

Old Generating Station



Minneapolis Steam Power Plant Showing Diversion Dam of Lower Dam Hydro-electric Plant.

sides of the two boilers with a removable section shafting installed making it possible to drive the feeder of both ash pits from either motor. The feeders discharge to the bucket conveyor as shown by the drawing. Cinders from a trap located between the boiler and economizer discharge to a small auxiliary hopper directly over the conveyor.

New Feed Heating Equipment

Then there were three feedwater heaters, a surge tank, make-up tank and evaporator to take care of in a building built before equipment of this kind was used. The masterly way in which this was accomplished is shown by the section, Fig. 2. The low-pressure heater is located in the turbine room basement, the high-pressure heater in a gallery on the firing floor and the direct contact heater on the second floor of the boiler room, just above the boiler feed pumps and immediately below the makeup tank. This makeup tank is supplied by a float controlled makeup pump taking its suction from the surge or storage tank in the basement. Normally load changes resulting in flow between boiler system and the surge tank is controlled from the water level of the direct contact heater by the remote control valves indicated in the lower right hand corner of Fig. 1.

Boilers

Each of the two new boiler units have 16,438 sq. ft. of heating surface, a convection superheater, a 3686 sq. ft. economizer, 14,176 sq. ft. tubular air heater and a forced and induced draft fan. Coal is supplied to the 168 t. bunkers by a pivoted bucket conveyor and the coal to each boiler is weighed by two Richardson coal scales. Ash is handled by the return conveyor through the reciprocating feeder arrangement mentioned above. Fig. 2 shows two coal conveyors and two stacks, the necessity for which is not apparent in the drawing.

Two conveyors were installed in the original plant, one for each side of the firing aisle. In the new section only one of the conveyors was needed to handle ashes and the right hand one of Fig. 2 had to be left in place to supply coal to the new boilers. In the original station each of the two stacks shown by Fig. 2 served three batteries of boilers. When the new boilers were added they were located so as to use the right hand stack in common with the remaining batteries of boilers. The left hand stack is used by the three opposite old boilers. Eventually these four old boilers will be replaced by a third large one which will be on the right hand stack. The remaining stack shown on Fig. 2 will then be completely out of service.

The new boilers have 8100 cu. ft. water cooled furnaces, fired by a 14 retort Westinghouse stoker with a projected grate area of 436.5 sq. ft. The stokers are capable of burning 55 lb. of Illinois coal per square foot of projected grate area, giving the boilers a maximum steaming rate of 175,000 lb. per hr. Total steam temperature is limited to a maximum of 735 deg. F. by Elliott desuperheaters (with Baily control) located at the superheater outlets.

From the boilers the steam header follows the center line of the old boiler room until opposite the turbine as shown by the plan Fig. 3. This is a 20,000 kw., 2100 r.p.m., 13,200 v., 3 ph., 35 cycle machine rebuilt in 1931 as explained above, the 35 cycle frequency accounting for the odd auxiliary drive speeds noticeable in the list of equipment.

As originally installed, all auxiliaries were turbine driven but these were changed to motor drive during the reconstruction. The hotwell pump unit was completely replaced but the circulating pump was retained

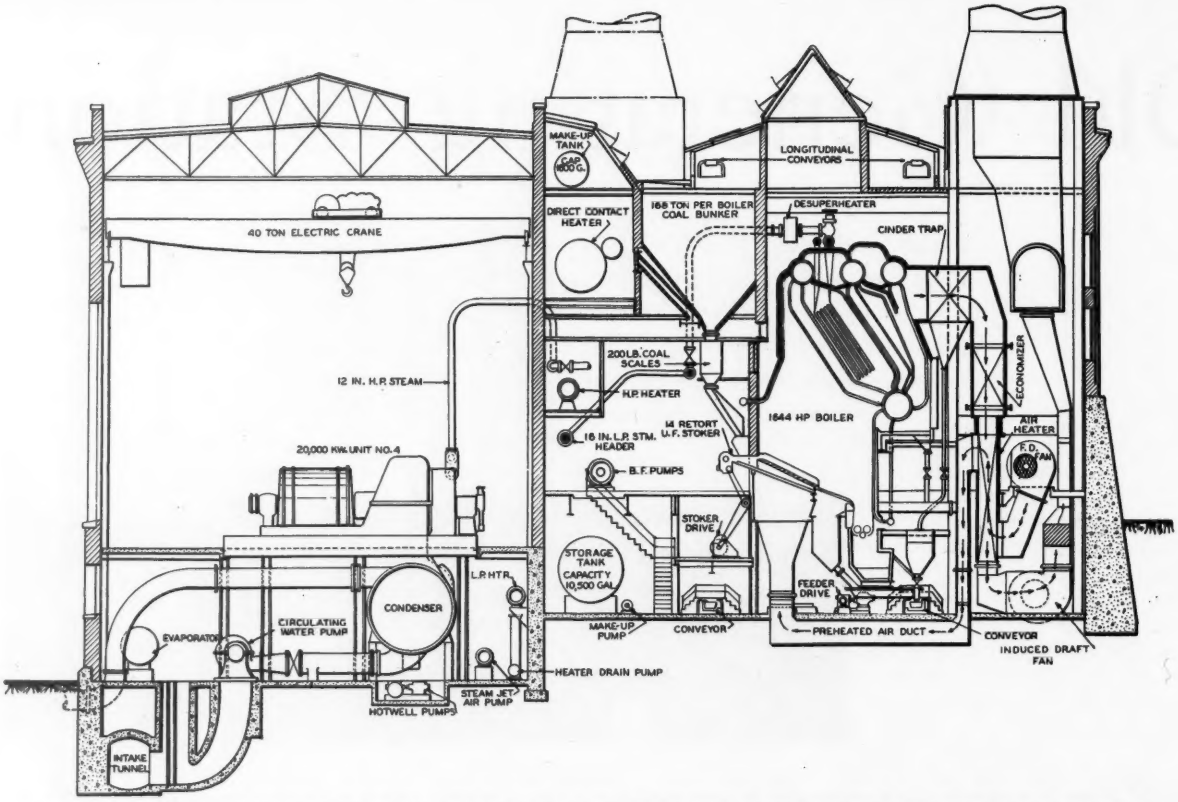


FIG. 2. CROSS SECTION OF THE PLANT TAKEN SO AS TO SHOW THE NEW BOILERS AND REBUILT TURBINE

but with a new motor drive. The speed was reduced somewhat but the capacity still is more than sufficient to handle the present steam load because in addition to the higher efficiency of the new boilers the steam flow to the condenser of the 20,000 kw. unit was cut to about 60 per cent of the flow with low pressure steam.

When the turbine was rebuilt, three bleed points were provided and are used as shown by the heat balance diagram Fig. 1. The first extraction point supplies the high pressure heater; the second supplies the evaporator and deaerating heater; and the third supplies the low pressure heater (which also acts as the evaporator condenser). At full load the second extraction point pressure runs around 27.5 lb. absolute and of course drops with the load. When the pressure in this line drops below 3 lb. ga. the direct contact heater and evaporator are supplied through a reducing valve from the first stage extraction line.

The high pressure heater drains through a trap to the direct contact heater; the evaporator drains to the low pressure heater and the low pressure heater is drained by a pump discharging to the outlet side of the heater. In an emergency this heater can discharge through a flash tank to the condenser as shown by the dotted line in Fig. 1. In the plant the evaporator is located in the turbine room basement at the outboard end of the generator.

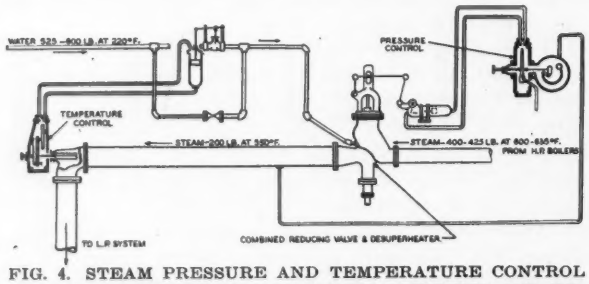

WATER 525 - 900 LB. AT 220°F.
PRESSURE CONTROL
TEMPERATURE CONTROL
STEAM-200 LB. AT 380°F.
STEAM-400-425 LB. AT 800-850°F. FROM H.R. BOILERS
TO L.P. SYSTEM
COMBINED REDUCING VALVE & DESUPERHEATER

FIG. 4. STEAM PRESSURE AND TEMPERATURE CONTROL ARRANGEMENT FOR THE COMBINED REDUCING AND DESUPERHEATER VALVE

Power generated in the plant is used for the street railway system and is distributed from the power plant to converter substations at generator voltage. The alternating current auxiliary power supply is taken through a bank of three 400 kv.a. single phase, 13,800/460 volt transformers and the 550 v. direct current, used on a number of drives such as the clinker grinders, ash feeders and stokers, is obtained from the nearby Lower Dam water power station and distributed through the steam station from two groups of dead front enclosed General Electric air circuit breakers. Delta connections for both the high and low sides of the transformers are located inside so that the spare unit can be cut in on the inside by shifting the connection bars.

The lighting system was also changed, a new lighting transformer being installed and the old direct current engine generator set formerly used retained for standby service. The old battery was scrapped and a new 55 cell Exide battery installed with a 10 kw. Diverter Pole trickle charger. The 55 rather than the more common 60 cell battery was necessary because of the original 110 control voltage of the old circuit breakers could not be operated satisfactorily on the higher voltage. The battery supplies all the small 110 v. direct current motors and the push button circuits on the 550 v. d.c. control.

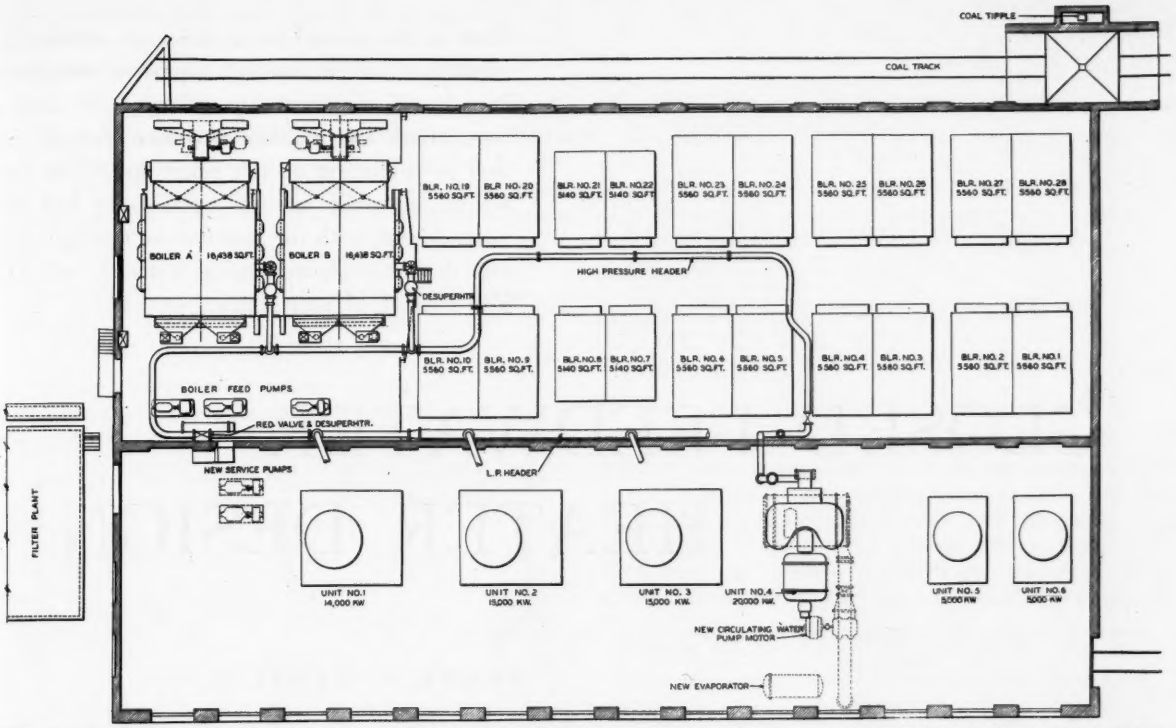


FIG. 3. PLAN SHOWING THE STEAM LINE ARRANGEMENT TO THE TURBINE AND THE CROSSOVER CONNECTION WITH THE LOW PRESSURE SYSTEM

PRINCIPAL EQUIPMENT FOR MINNEAPOLIS POWER STATION

Owners: Minneapolis Street Railway Co.
Service: Power for Street Railways.
Location: Minneapolis, Minn.
Consulting Eng.: Sargent & Lundy, Inc.

Boilers—Babcock & Wilcox Co., 2, 400 lb. gage, 735 deg. F., 16,438 sq. ft., 4 drum, 3 pass, Stirling boilers with a maximum steaming capacity of 175,000 lb. per hr. Convection superheaters.

Furnaces—Babcock & Wilcox Co., 2, Bailey water cooled with a furnace volume of 8100 cu. ft. Maximum heat liberation 29,400 B.t.u. per cu. ft.

Economizers—Babcock & Wilcox Co., 2 forged steel return bend type with heating surface of 3686 sq. ft. each.

Stokers—Westinghouse Electric & Mfg. Co., 2, 14 retort underfeed with link grate and clinker grinder. Projected grate area 436.5 sq. ft. Coal burning capacity 55 lb. of Illinois coal per sq. ft. of projected grate area.

Air Heaters—Babcock & Wilcox Co., 2, tubular with a heating surface of 14,176 sq. ft. each.

Soot Blowers—Diamond Power Specialty Corp.

Cinder Trap—Dust Recovery, Inc.

Boiler Settings—Michael Liptak.

Forced Draft Fans—Buffalo Forge Co., 2, super turbo, driven by 2 speed 1015/508 r.p.m. squirrel cage induction motor. Capacity at higher speed with 80 deg. F. air 55,000 c.f.m. against a static pressure of 7 in. of water.

Induced Draft Fans—Buffalo Forge Co., 2 super duplex, driven by 2 speed 1020/510 r.p.m. squirrel cage induction motors. Capacity at higher speed with 400 deg. F. flue gas 100,000 c.f.m. against a static pressure of 7.5 in. of water.

Damper Control—A. W. Cash Co.

Ash Handling Equipment—Beaumont Mfg. Co., consisting of 2 ash pits made from ⅝ in. copper steel plates, 8—4 ft. stroke by 3 ft. wide roller gates and 8 reciprocating feeders operated by d.c. motors.

Coal Spouts—Rolland Gardner & Co.

Coal Scales—Richardson Scale Co., 2 per boiler. Capacity 200 lb. or 6 t. per hr. each.

Coal Gates—Henry Pratt Co.

FEEDWATER HEATING EQUIPMENT

Low Pressure Heater—Whitlock Coil Pipe Co., 4 pass, horizontal, floating head type with a heating capacity of 175,000 lb. per hr. from 70 to 182.4 deg. F. Effective heating surface of 1200 sq. ft. made up of ⅝ in., 16 B.w.g. copper tubes.

Deaerating Heater—Hoppes Mfg. Co., direct contact, horizontal type with a capacity of 400,000 lb. per hr. from 160 to 216 deg. F., working pressure 25 lb. per sq. in. gage storage capacity 3000 gal. Complete with a single pass vent condenser with ⅝ in. No. 18 B.w.g. copper tubes.

High Pressure Heater—Foster Wheeler Corp., 4 pass, horizontal, floating head type with heating capacity of 350,000 lb. per hr. from 212 to 285 deg. F. Heating surface of 800 sq. ft. made up of ¾ in., 16 B.w.g. arsenical copper tubes.

Evaporator—Foster Wheeler Corp., horizontal with 484 sq. ft. of heating surface made up of 1 in., 16 B.w.g. arsenical copper tubes. Disengaging surface, 65 sq. ft. Capacity 10,000 lb. per hr.

PUMPS

Boiler Feed Pumps—Ingersoll-Rand Co., 3, 5 stage centrifugals with a capacity of 400 g.p.m. against a 600 lb. pressure at 2020 r.p.m., 2 pumps driven by 250 hp. Westinghouse squirrel cage motors, one driven by a 220 hp., type 2AMD Westinghouse steam turbine.

Hotwell Pump—Foster Wheeler Corp., 1 horizontal, 2 stage, 4 in. with a capacity of 450 g.p.m. at 170 ft. head. Driven at 2000 r.p.m. by a squirrel cage motor.

Heater Drain Pump—Foster Wheeler Corp., 1 horizontal, 2 in., 2 stage with a capacity of 80 g.p.m. at 140 ft. head. Driven at 2000 r.p.m. by a squirrel cage motor.

Make Up Pump—Foster Wheeler Corp., 2 horizontal, single stage, 2 in. with a capacity of 100 g.p.m. at 100 ft. head. Driven at 2000 r.p.m. by squirrel cage motors.

Vacuum Pump—Foster Wheeler Corp., one 3 element, 2 stage, steam jet with a combined inter and after cooler and an air capacity of 30 c.f.m. at 1 in. abs.

River Water Pump—Worthington Pump & Machinery Corp., 1 horizontal, single stage, 6 by 4 in. with a capacity of 175 g.p.m. at 128 ft. head. Driven at 2040 r.p.m. by a squirrel cage motor.

Filtered Water Pump—Worthington Pump & Machinery Corp., 1 horizontal, single stage, 6 by 4 in. with a capacity of 750 g.p.m. at 180 ft. head. Driven at 2040 r.p.m. by a squirrel cage motor.

PIPING AND MISCELLANEOUS

Piping System—Pittsburgh Piping & Equipment Co.

Feedwater Regulators—Swartwout Co.

Pressure Reducing Equipment—H. A. Brassert Co., consisting of desuperheating and pressure reducing equipment with Askania Regulators and Schutte & Koerting combined reducing and desuperheating valve.

Distilled Make Up Water Tank—Wm. Bros Boiler & Mfg. Co.

Flues & Ducts—Wm. Bros Boiler & Mfg. Co.

Insulation—G. A. McArthur Co.

Steel & Iron Work—L. W. Myers Co.

Boiler & Turbine Room Instruments—The Bristol Co.

CO_2 Indicators—Republic Flow Meters Co.

Temperature Recorders—Brown Instrument Co.

Flow Meters—Brown Instrument Co.

Venturi Meters—Simplex Valve & Meter Co.

Water Meters—Hersey Mfg. Co.

Draft Gages—Hays Corporation.

Gage Boards—Variety Fire Door Co.

Turbine—1, General Electric Co., 13,200 v., 35 cycle, 20,000 kw. unity power factor generator driven at 2100 r.p.m., by 8 stage 400 lb. gage, 725 deg. F., steam turbine exhausting at 1 in. abs. This machine was originally installed in 1916 to operate at 200 lb. gage, 550 deg. F. but was rebuilt in 1931 for the higher pressure and temperature.

Coal Conveyor—J. A. Mead & Co., 2 McCaslin bucket type with a capacity of 75 t. per hr. installed with the original plant about 1900.

Condenser—Westinghouse Elec. & Mfg. Co., 2 pass, 33,000 sq. ft. surface with 1 in. dia., 18 B.w.g. tubes 16 ft. 2½ in. long, packed at the inlet end with corset lace packing and at the outlet with John Crane fibre rings.. The condenser was installed in 1916 with turbine.

Desuperheaters—2, Elliott Co. with Bailey control.

Valves—Crane Co. gate valves, Edward, globe and angle.

High Pressure Heater Drainer—Mercon Regulator Co.

Circulating Pumps—Westinghouse Elec. & Mfg. Co. Cap., 32,000 g.p.m. at 16 ft. head, originally installed in 1916 with turbine drive which was changed to a 2100 335/405 r.p.m., 200/225 hp. induction motor.

Steam Valve Motor Control—Cutler-Hammer Co., Inc.

Smoke Detector—General Electric Co.

Storage Battery—Electric Storage Battery Co. EMGO-13, 55 cell closed type, 8-hr. rate 30.7 amp. with 10-kw. diverter pole charging set.

POWER PLANT ENGINEERING May 1933

This is the second of a series of articles on extraction heaters and will appear in two parts, Part I will deal with the selection of surface tube length and number of passes, Part II will deal with friction on the water size. The first article appeared in the April issue and the next, dealing with the installation, testing, venting, draining, piping and accessories, will follow Part II of this article.

CLOSED FEEDWATER HEATER DESIGN

By
FRANK R. WHEELER

MODERN POWER PLANTS employing stage heating of boiler feedwater by the use of steam extracted from one, or more, pressure stages of the turbine, revived the use of closed feedwater heaters and called for accurate proportioning of the surface, tube size, tube length and number of passes. The closed type of heater as generally used for this purpose, consists of a shell containing a bundle of tubes with the heating steam in the shell surrounding the tubes and the feedwater pumped through the tubes in one or more passes.

Obviously the heating steam is condensed by giving up its latent heat to the water. The function performed by the heater is the same as that of a surface condenser, but the heat transfer values used in condenser design are not applicable because we are dealing with steam at higher pressure and density, and with water at higher temperature with a corresponding lower viscosity and density. All these factors have an effect on heat conductivity.

Values of the factor overall heat transfer coefficient U are most important and there are little published data available. It is hoped that this contribution will be of use to consulting engineers and designers in writing specifications consistent with commercially attainable results as Fig. 2, which gives values of U as a function of velocity and film temperature, is the result of a combined study by several engineers from the staffs of the most prominent manufacturers of heaters. These values, which have been proved to give results attainable in commercial practice, are used by manufacturers for guarantees.

It can be demonstrated that this overall heat transfer coefficient U is a function of: Velocity; density of the flowing fluid; viscosity of the flowing fluid; tube size; tube length; conductivity of the steam film; conductivity of the metal tube wall; conductivity of the water film adjacent to the tube wall; temperature of the water film.

FRANK R. WHEELER graduated from Stanford University in 1902 and for over thirty years has been closely identified with condenser and heat transfer equipment. Few men in any industry are privileged to play such an important and many sided role in their chosen work and become so widely acquainted in all sections of the country. Following general engineering experience as vice-president of the Tracy Engineering Co. in California, Mr. Wheeler, in 1906, became Pacific Coast Manager of C. H. Wheeler Manufacturing Co. and in 1910 Chicago District Manager. He left Chicago in 1928 to become Manager of the Condenser and Heater Departments of the Elliott Co. at Pittsburgh and returned to Chicago as Special Middle Western Representative of the Worthington Pump and Machinery Corp. in 1932.

Since the war the many variables affecting heat transfer in heaters of this type have been investigated from a theoretical standpoint and Mr. Wheeler has been active in applying and interpreting this experimental work for commercial applications. His efforts in this direction, combined with that of other interested engineers led to what is perhaps the greatest commercial advance made in this industry, the agreement, by the interested manufacturers, of practical heat transfer coefficients as a function of the water velocity and film temperature as given by the curves in Fig. 2 of this article.

It can be demonstrated that this overall heat transfer coefficient U is a function of: Velocity; density of the flowing fluid; viscosity of the flowing fluid; tube size; tube length; conductivity of the steam film; conductivity of the metal tube wall; conductivity of the water film adjacent to the tube wall; temperature of the water film.

A careful and extended consideration of all these variables as applied to commercial design of feedwater

heaters indicates that water film temperature and velocity are the principal controlling factors and that water film temperature may be satisfactorily represented by

$$T_f = T_s - 0.8\ D_m \qquad (1)$$

It should be noted that values of U given by Fig. 2 are for pure water or steam condensate, so that for raw water, 85 per cent, and for tubes 1 in. diameter 90 per cent of the values shown should be used in calculations.

Fundamental Equations

The fundamental equation of a heat exchanger of this type is:

$$W\ (T_2 - T_1) = S\ U\ D_m \qquad (2)$$

In cases where the terminal difference $T_s - T_2$, is large, it would be permissible to use the arithmetic mean

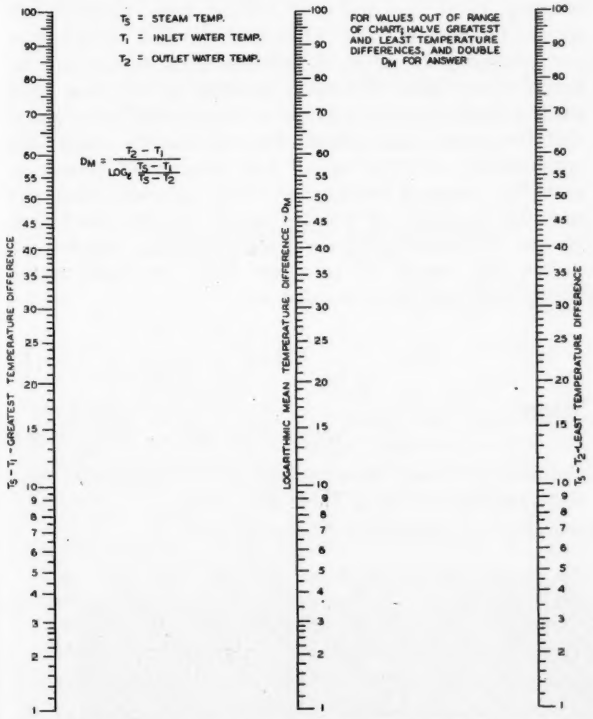

T_s = STEAM TEMP.
T_1 = INLET WATER TEMP.
T_2 = OUTLET WATER TEMP.
$D_M = \frac{T_2 - T_1}{\log_e \frac{T_s - T_1}{T_s - T_2}}$
FOR VALUES OUT OF RANGE OF CHART, HALVE GREATEST AND LEAST TEMPERATURE DIFFERENCES, AND DOUBLE D_M FOR ANSWER
$T_s - T_1$ - GREATEST TEMPERATURE DIFFERENCE
LOGARITHMIC MEAN TEMPERATURE DIFFERENCE = D_M
$T_s - T_2$-LEAST TEMPERATURE DIFFERENCE

FIG. 1. CHART FOR DETERMINING THE LOGARITHMIC MEAN TEMPERATURE DIFFERENCE

temperature difference. In cases of extraction heating, however, the greatest practical heating effect is desired and this means the reduction of the terminal difference to the lowest value consistent with the cost of increased surface needed to attain the effect. For this condition of operation it is necessary to use the logarithmic mean to give the necessary accuracy.

The temperature difference, D_m, is the first unknown in any problem but having given T_s T_1 and T_2, it may be calculated from Eq. 2A,

$$D_m = (T_2 - T_1) \div \text{Log}_e \frac{T_s - T_1}{T_s - T_2} \qquad (2A)$$

or found graphically by using Fig. 1. The heat transfer coefficient U can then be found from Fig. 2, where it is shown as a function of the temperature difference, D_m, and the velocity, V. Substituting the value of D_m in Eq. 2 and transposing, gives

$$S = \frac{W}{U} \text{Log}_e \frac{T_s - T_1}{T_s - T_2} \qquad (3)$$

Where, in these and the following equations,

W=Water heated in lb. per hr.
S=Surface in sq. ft.
U=Overall heat transfer in B.t.u. per sq. ft. per deg. F. mean temperature difference
T_s=Saturated steam temperature in deg. F. (Neglect superheat)
T_1=Temperature of water to heater in deg. F.
T_2=Temperature of water from heater in deg. F.
D_m=Log. mean temperature difference in deg. F.
T_f=Temperature of water film in deg. F.
d=Inside diameter of tube in in.
D=Outside diameter of tube in in.
z=Viscosity of water at film temperature, centipoises
s=Specific gravity, referred to water at 39.2 deg. F.
H=Loss of head in feet of water
V=Velocity of water in tube, ft. per sec.
L=Length of one pass in ft.
n=Number of passes

Tube Size and Wall Thickness

Where the hydraulic pressure is over 350 lb., care must be used in the selection of the tube size and gage, particularly with water temperatures exceeding 300 deg. F. Unsteady pressures and shock loads must be avoided in all cases. Table I gives comparative working pressures based on Muntz metal tubes and factors of safety of 10, 15 and 20 for the three temperatures indicated.

TABLE I. RECOMMENDED WORKING PRESSURES FOR MUNTZ METAL TUBES AT DIFFERENT TEMPERATURES

Tube Diam.	B.w.g.	MAXIMUM TEMPERATURE, DEG. F. 300	450	500
½"	13	2450	1625	1225
	14	2025	1350	1000
	15	1600	1075	800
	16	1400	925	700
	17	1200	800	600
	18	975	650	485
⅝"	13	1750	1150	875
	14	1500	1000	750
	15	1200	800	600
	16	1050	700	525
	17	900	600	450
	18	750	500	375
¾"	13	1360	900	680
	14	1150	775	575
	15	950	625	475
	16	840	560	420
	17	730	490	370
	18	600	400	300
⅞"	13	1100	740	550
	14	960	640	480
	15	790	525	390
	16	700	465	350
	17	610	400	300
	18	500	340	250
1"	13	1000	665	500
	14	810	540	400
	15	675	450	335
	16	600	400	300
	17	525	350	260
	18	430	290	200

Complete data on tubes of various sizes and gages most frequently used in heater and condenser practice will be given in Table III, Part II, to facilitate calculations in design problems.

Example

Equation 3 for finding the surface of the heater has been plotted as a chart, Fig. 3, the use of which is best shown by a practical example. Assume a heater is desired to heat 90,000 lb. per hr. of water from 94 to 206 deg. F. using saturated steam at 212 deg. F. The hydraulic circuit will be under 900 lb. pressure. Space limitations are such that the heater cannot be over 19 ft. overall length and the pressure drop must not exceed 10 lb. per sq. in. From Table I, ⅝ in., No. 16 B.w.g., or ¾ in. No. 15 B.w.g. tubes may be selected and in our first trial, we will use the ⅝ in. size. It is necessary

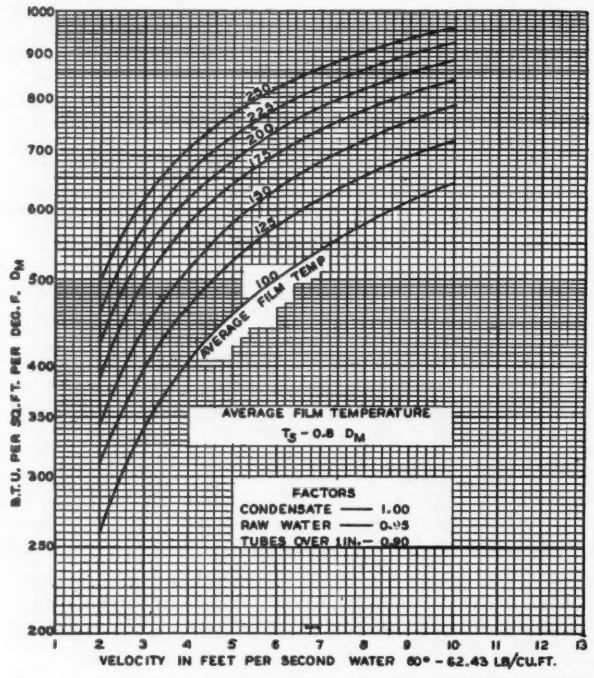

B.T.U. PER SQ.FT. PER DEG.F. D_M
AVERAGE FILM TEMP
AVERAGE FILM TEMPERATURE
$T_S - 0.8\ D_M$
FACTORS
CONDENSATE —— 1.00
RAW WATER —— 0.95
TUBES OVER 1 IN. — 0.90
VELOCITY IN FEET PER SECOND WATER 60° - 62.43 LB/CU.FT.

FIG. 2. OVERALL HEAT TRANSFER COEFFICIENTS FOR DIFFERENT FILM TEMPERATURES AS A FUNCTION OF THE VELOCITY

to assume a water velocity, which we will take as 6 ft. per sec. We have given, therefore,

W = 90,000	V = 6
T_s = 212	D = 5/8 (16 B.w.g.)
T_1 = 94	d = 0.495
T_2 = 206	L = 19 (less water
Press. drop = 10 lb.	box depths)
max. = 23.1 ft.	

By calculation and from charts, we get:

$T_s - T_1 = 118$
$T_s - T_2 = 6$
D_m (from Fig. 1) = 36.78
$T_f = 212 - 0.8 \times 36.78 = 182.6$
U (from Fig. 2) = 700

The necessary surface is found from Fig. 3. Enter the chart at the bottom at the greatest temperature difference, 118; pass vertically to the least temperature difference, 6; then horizontally to the value of heat transfer, 700; again vertically to the amount of water to be heated, 90,000; and horizontally, to the left hand margin, we find the necessary surface required, 380 sq. ft.

It was necessary to assume a water velocity to get a value of overall heat transfer. Velocity is a function of quantity of flow and cross section area (number and size of tubes) per pass. Therefore, further calculations are necessary to select the details of a heater of the specified surface. We have selected a tube size and gage suitable for the hydraulic circuit and have given definite length limitations, but we do not know the combination of tube length and number of passes to give the assumed velocity of 6 ft. per sec. with the specified quantity of water passing through the tubes. It can be shown that the product of the number of passes and length of tube per pass (or total water travel) LN can be expressed as:

$$LN = \frac{1}{U/V} K \log_e \frac{(T_s - T_1)}{(T_s - T_2)} \qquad (4)$$

Where

$$K = 4672.5\ d^2 \div D \qquad (5)$$

Values for K have been calculated for commercial tube sizes and are given in Table II.

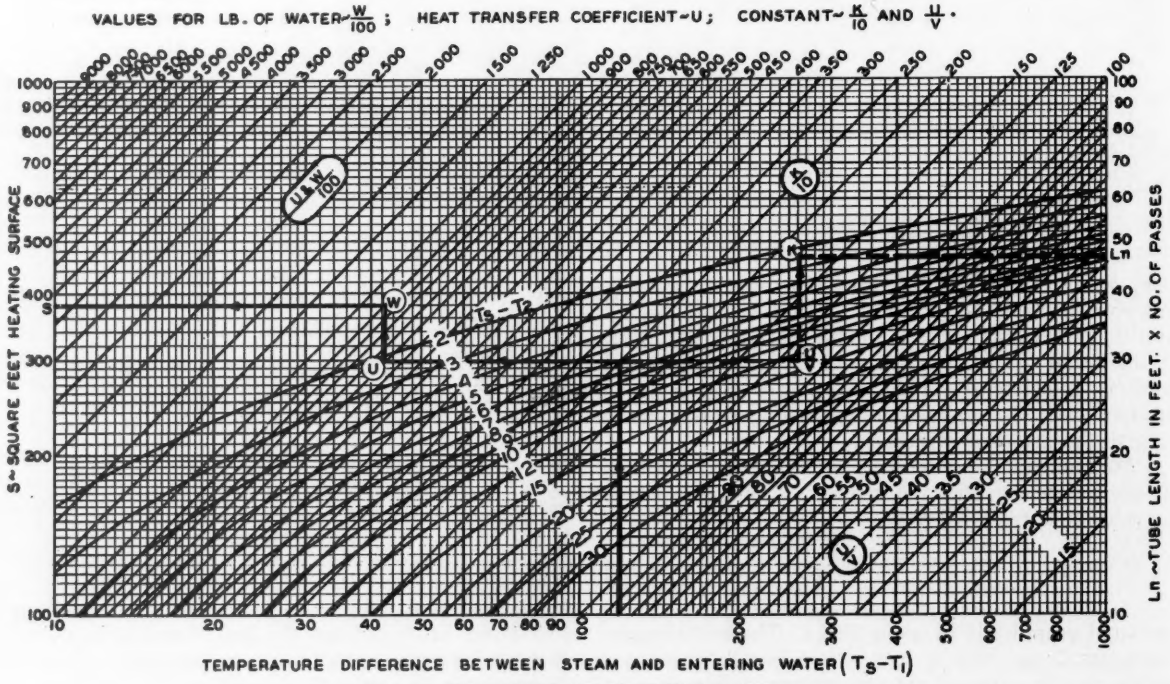

VALUES FOR LB. OF WATER ~ W/100 ; HEAT TRANSFER COEFFICIENT ~ U ; CONSTANT ~ K/10 AND U/V.
S ~ SQUARE FEET HEATING SURFACE
LN ~ TUBE LENGTH IN FEET X NO. OF PASSES
TEMPERATURE DIFFERENCE BETWEEN STEAM AND ENTERING WATER ($T_S - T_1$)

FIG. 3. CHART FOR SOLVING EQS. 3 AND 4.

Note that the figures at the top, evaluating the diagonal lines, are for U, U ÷ V, K and W. For U and U ÷ V the values apply directly but that the figures represent K ÷ 10 and W ÷ 100. For instance in the example W is equal to 90,000 not 900 and K = 1851, not 185.1.

TABLE II. VALUES OF K AS USED IN EQS. 4 AND 5

B.w.g.	Outside diameter of tubes in inches				
	½	⅝	¾	⅞	1
13	897	1414	1553	2505	3064
14	1080	1575	2126	2683	3250
15	1184	1750	2287	2853	3463
16	1297	1851	2397	2962	3536
17	1378	1937	2505	3078	3222
18	1510	2072	2648	3222	3800

Our problem gave the tube size as ⅝ in. and the gage as No. 16. We find from Table II that K = 1851 and by calculation we now obtain a value U ÷ V = 700 ÷ 6 = 116.67, so that we can also use the chart Fig. 3 to obtain a value of Ln, the product of the tube length and number of passes. Enter the chart again at the value of $(T_s - T_1) = 118$, pass vertically to the value of $(T_s - T_2) = 6$; horizontally to the value of U ÷ V = 116.67; vertically to the value of K = 1851; and horizontally to the value Ln, which is found to be 46.8.

Our heater, to give this product, may be:

Single pass with tubes 46.8 ft. long
Two pass with tubes 23.4 ft. long
Three pass with tubes 15.6 ft. long
Four pass with tubes 11.7 ft. long

We have already stipulated that the overall length of the heater shall not exceed 19 ft., therefore allowing for water boxes, we select the three pass design with tubes 15.6 ft. long.

A similar analysis can be made for a heater with ¾ in., No. 15 B.w.g. tubes. From Table II, we find K for this tube size to be 2287 and using Fig. 3 as before, we find Ln = 58.2, so the heater may be

Two pass with tubes 29.1 ft. long
Three pass with tubes 19.4 ft. long
Four pass with tubes 14.55 ft. long

The four pass heater is necessary to keep within the maximum length. The final selection of a heater with ⅝ or ¾ in. tubes would depend on first cost and pumping head of the respective heaters. The heater with ¾ in. tubes would require a larger tube bundle, in this case in the ratio of about 16 to 14, and, with the same velocity, the friction head would vary as the value of $Ln \div d^{1.25}$, or as 108 to 112, approximately 4 per cent less than the heater with ⅝ in. tubes. Calculation of the friction loss through the tubes and in the water boxes will be covered in Part II of this article.

Surplus Power*—Availability, Cost and Economic Disposal

By A. G. Christie**

EVERY POSSIBILITY of power is at present being given careful consideration to determine the probable savings from its purchase or sale, with the result that one may safely predict steadily increasing development of surplus power. The questions arise: What is surplus power? Under what conditions is it available? How much does it cost to produce? What is its market value? When can power be economically interchanged?

For the purpose of this discussion, surplus power is defined as that which an industry or a utility may at times have available from either hydro-electric or steam generating plants in excess of its own requirements.

River flow conditions may make surplus hydro-power available at other than full flow periods. Off-peak periods at night and at other hours render capacity available for the generation of surplus power. Such generation of power at irregular odd periods may be called "random surplus power."

At times, public utilities have excess capacity available in steam generating stations. For instance, the night loads of every utility from about 10 p. m. to 6 a. m. are far below peak capacity and generally much below the load at which the station can be operated at best economy. Losses from banking boilers and from starting-up and shutting-down turbines will be saved, if these are kept in continuous operation, hence the utility may be fully justified in offering supplies of off-peak power at low rates based on the incremental cost of production and service.

If fixed charges on the plant are distributed over those loads that contribute to the maximum peak demand of the year, surplus power, being generated with otherwise idle capacity and during off-peak periods, need bear none of these fixed charges and can generally be produced at comparatively low cost.

It sometimes occurs that a hydro power site has been developed with a potential capacity in excess of present requirements. If, for instance, "firm" or all-year-round capacity of a site is 60,000 kw. but only half this capacity is required by the present mill so that only 30,000 kw. of generating plant has been installed, the incremental cost of equipment for 30,000 kw. additional capacity would include the purchase price of turbines, generators and electrical equipment, together with the expense of installation. This may be small compared to the complete investment in dam, water rights, leases and power house. Fixed charges on the additional equipment are part of the cost of surplus power; added operating costs for labor and maintenance, always a small factor in hydro plants, form another part of the cost of this additional 30,000 kw.; allowance for profit, taxes, insurance and the like completes the costs, the total for the surplus power usually being so low as to induce a ready sale. This low selling price can be justified by the owner, for he is earning a profit on his additional investment over fixed and other charges, from the sale of 30,000 kw. that would otherwise be wasted.

In an industrial plant, power produced in a turbine which serves as a reducing valve to a process demand for steam, can be generated for about 4500 B.t.u. per kw-hr. in additional fuel, or roughly for about ⅓ lb. of coal per kw-hr., less than in any central station. Other costs chargeable to surplus power would be: Fixed

*From a paper before the Technical Association of the Pulp and Paper Industry.

**Professor of Mechanical Engineering, Johns Hopkins University, Baltimore, Md.

charges on the excess in first cost of the high-pressure plant over a low-pressure plant which would be just sufficient to furnish the industry's steam and power demands; additional repairs and maintenance, if any, of such high-pressure plant; fixed charges on the cost of extra capacity of the turbo-generator required to deliver surplus power.

Availability of Power Supply

If this surplus power is to be sold as "firm" or continuous power, the industry must be certain that it can supply such energy to a utility or other customer at all times, regardless of business conditions in the industry. If continuous service can be guaranteed over a term of years and if the industrial plant is prepared to co-operate with the utility to maintain voltage regulation and to plan operations to secure the best system performance, this "firm" or base surplus power has a value equal to the sum of the fixed and operating costs upon equivalent central station capacity, which will be saved by the utility. This value should yield a good profit to the industrial plant in many cases.

On the other hand, if surplus power is available only in irregular amounts at random times, it is virtually "dump" power and its value is only the incremental cost of developing an equivalent amount of power in the utility's plants, generally a small figure, not warranting investment in extra turbo-generator plant.

But, if the capacity of the turbo-generator plant is fixed by the industry's maximum demand and demand of the industry for steam frequently exceeds that for power, saleable surplus power can be developed from the excess steam at a total cost of only the fuel consumed for power, i.e., about ½ lb. of coal per kw-hr. This is about the cheapest power that can be generated from steam and its sale at any incremental cost to the utility should prove profitable to the industry. Size of supply is relative only. While 500 kw. may be of no importance to a large metropolitan system, it would prove a significant and welcome addition to many a small utility.

Surplus power can be made available from public utilities at its incremental fuel, labor and maintenance costs, plus an allowance for transmission losses and for service charges and a reasonable rate of profit. The rate charged, bearing none of the fixed charges on the main plant equipment, would be low as compared to the regular rate schedules for power supply.

Sales Value of Surplus Power

Probable sales value of surplus power cannot exceed the cost to the purchaser of procuring an equal supply from another source. If a utility secures its power from hydro sources, it would be interested in a supply from an industrial plant of only "firm" surplus power, as for instance, in the excess 30,000 kw. in the example already noted. The value to the utility of such power would depend upon the cost of developing an equal supply at one of its present plants or at a new site.

Should the utility operate steam-generating stations, with the necessary capacity to carry its peak load, it can afford to pay for surplus power a price equal only to the incremental operating cost of generating the same capacity in its own stations, including fuel and certain portions of the costs of labor, repairs, and maintenance. In general, this is not large, as modern plants generate a kilowatt-hour on 1 to 2 lb. of coal and added labor and other charges are small.

If, however, the utility needs additional capacity, which must be secured by building an extension to one of its plants or by the purchase of surplus "firm" power, the latter possesses quite another value. In this case the incremental cost to the utility to furnish this power by the extension of its own plant will include fixed charges on the added equipment as well as fuel, labor, repairs, and maintenance charges. These may double the value of the surplus power from the industrial plant over the preceding case. In order that the utility be justified in purchasing such power under these conditions, it would appear desirable to make the term of the contract equal to the average life of steam station equipment, i.e., from 16 to 20 yr. Otherwise, the investment in the utility's plant is simply postponed for the shorter period.

At times, utilities have surplus power for sale, as in case of the development of a large hydro site whose total capacity is much in excess of the immediate needs of the utility but will be required at a future date. Such surplus power is available in decreasing amounts as the utility's load grows, hence the purchaser of such power must make other provision for his needs as the available surplus decreases.

Interchange of Power

Cases frequently arise where an industrial plant has surplus power available at one time of the year and, at another time, may find it profitable to use power from the utility. For instance, a northern plant with a large space-heating load, may have potential surplus power available in winter. In summer it may be better to take power from the central station and to curtail the operation of the industrial plant. Summer loads on central stations seldom approach the peak capacity, hence ample idle capacity is available to furnish such needs in summer.

It is evident from the previous analysis that it may be inequitable to expect utility and industrial plants to interchange power on a kilowatt-for-a-kilowatt basis, since the utility must include certain distribution costs in its charges for surplus power.

Interconnection may have other values, as for instance, in providing reserve for both parties in emergencies.

Cases also arise where an industrial plant desires to take central station service at other than off-peak hours. If required throughout the year, this must be paid for at the usual rates, but a customer for summer service only should be entitled to energy at the increment cost of fuel, labor and maintenance, since fixed charges must be paid by the other parts of the system regardless of whether this surplus power is sold or not and since this customer does not contribute to the yearly peak load for which plant capacity must be provided.

Agreements for the sale or interchange of surplus power should be based only on the cold hard facts of each case. The performance figures and complete costs of both parties should be presented and considered and values for power based on figures which represent true costs to each party. Such negotiations must consider dollars and cents and must be devoid of emotional appeal and cut-throat bargaining. Equitable rates and fair contracts usually prove satisfactory and profitable to both parties.

New Stoker Technic Developed for Lignite

Short Fire Method Uses Only One of the Six Zones on a Chain Grate Stoker and the Fuel is Burned in Suspension. By G. W. Welch, Chief Engineer, Otter Tail Power Co., Fergus Falls, Minn.

CONSIDERABLE experimental work has been carried on at the Kidder* and Washburn Stations, looking towards improved methods of handling and burning lignite coal, particularly with regard to bettering the furnace efficiency and pick up. Out of this work has come the so-called short fire which is a radical departure from previous methods of operating travelling grate stokers.

Briefly, this method consists in introducing most of the combustion air supply through one stoker zone, under a static pressure of 2 to 4 in., depending on the rating. It is preferable, with the type of furnace used, to operate on the third zone, although any zone from number one to number four may be used. The fuel is fed in at a uniform depth of 8 to 16 in., according to rating. Some surface ignition occurs over the initial zones and a slight amount of air is here admitted to carry off the considerable amount of distilled volatiles and permit their partial combustion under the front arch. The fuel bed travels backwards in a practically undisturbed state, however, until it reaches the blast zone.

Here the entire mass is blown from the grate and is practically all burned in suspension, violent combustion taking place from the grate surface, up through the throat and into the upper chamber. A few of the larger fuel particles, in an incandescent state, fall back towards the rear of the grate, where a small quantity of air is admitted, as necessary, to burn them out completely. The fuel bed cuts off squarely at about the middle of the blast zone and the flame sheet naturally inclines backwards at an angle of some 40 deg. from the vertical, so that when firing on the third zone, it is projected straight into the furnace throat.

Studies of the flame action have been made with both still and movie cameras, equipped with suitable color filters and using special red sensitive film, which clearly show the action taking place in the flame. The fine particles ignite almost instantly and disappear, while the coarser fuel is literally floated by the air blast until consumed. The throat restriction quite evidently assists the action by maintaining the gas velocity and confining the stream of burning fuel until it reaches the upper chamber, where combustion is completed.

In the photograph, Fig. 1, taken at Kidder Station through a rear observation door with the camera facing towards the front of the boiler, the floating particles are clearly seen, each with its characteristic plume of flame. The well known tendency of lignite to slack, or disintegrate to fine dust under oxidation, is evidently greatly accelerated in the high temperature flame and this action materially assists in promoting rapid combustion. On close inspection of the photograph the fuel bed can be seen advancing towards the camera behind the flame. Seen with the naked eye, the flame appears as a solid incandescent mass of great brilliance and no details can be made out. The picture was taken at about 200 per cent rating with a fuel bed 8 in. thick.

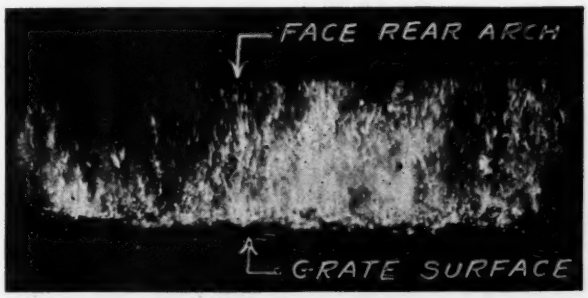


FIG. 1. VIEW THROUGH THE REAR DOOR AT KIDDER STATION 200 PER CENT RATING

With a given load and forced draft pressure, control of combustion is effected by changing the stoker speed; increase of speed tending to advance the cut-off point over the blast zone and reduce the air flow, which causes a rise in the CO_2. Conversely, reducing stoker speed retards the cut-off point, resulting in admission of more air and reducing the CO_2.

Furnace conditions with the short fire approximate those obtained with pulverized coal as regards flexibility of control and quick pick-up and there is also a gain of several points in the over all efficiency. The method has one advantage over the straight pulverized system in that it permits carrying a banked fire and holding a boiler under steam indefinitely. It has been repeatedly demonstrated that a banked unit can be put on the line and be carrying ratings of 200 per cent or better in less than 15 min. Temperatures average very much higher than with old methods of firing, in fact reaching values,

*See Power Plant Engineering, page 110, March 1933 for a description of this station.

at the higher ratings, which may cause serious destruction of refractories. Surveys with an optical pyrometer on one 500 hp. unit at 300 per cent showed throat temperatures of 2400 deg., as compared with maximum long fire temperatures of 1900 deg. with equal rating. As lignite carries considerable amounts of iron and lime and the usual ash fusion temperature will average around 2300 deg., these higher furnace temperatures will cause fluxing of the refractory lining, with consequent erosion, and there will be heavy slag formations at points in the furnace.

Water walls could not be used for long fire operation, since the reduction of furnace temperature would interfere with proper ignition, but the picture is quite different with the short fire and considerable water wall surface has recently been installed in No. 3 furnace at Washburn with excellent results. It is expected that all remaining units will be equipped with water walls in the near future.

Some recent results obtained with the No. 3 unit at

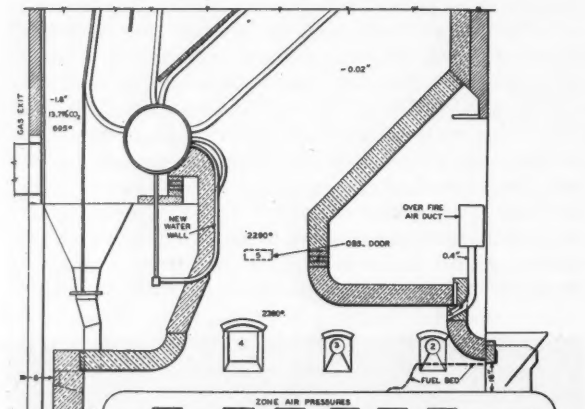


FIG. 2. FURNACE AT WASHBURN STATION

Photographs Figs. 3 to 6 were taken from the points marked above. Note that the camera was on the far side of the furnace looking out so that the left hand side of the picture represents the front of the furnace

Washburn with the newly installed water wall surface are of peculiar interest as regards the flame action in the furnace. A cross section of this furnace is shown by Fig. 2, with several photographs, Figs. 3 to 6, taken at different points. The various observation openings in the setting are shown numbered to identify the different camera locations. The draft and pressure readings, together with the temperatures noted on the drawing were taken during the time of making the pictures, while the unit was operating around 300 per cent rating and producing an average output of 50,000 lb. per hr. The approximate over all efficiency of the unit, figured from coal weights and flow meter readings, was 71 per cent. Firing was on the second zone, with a 16-in. fuel bed and draft pressures as shown. The beneficial effect of the water wall was very evident in the lowered throat and exit gas temperatures and operation over a period of several weeks has indicated that there is a great reduction, if not a complete absence of side wall erosion. Slag conditions on the walls and arches appear much improved.

Figure 3 shows at the left, the main flame which originates at the rear edge of the No. 2 stoker zone. The angle of inclination is evident. The dark spots are larger particles of fuel which are moving towards the right (rear) at a flatter angle and have not yet become ignited. Motion pictures made at this point show that the visible particles are travelling at very high speed. Most of these particles are burned in the secondary flame zone, where all are ignited. A small number, projected through the secondary zone, will strike the rear arch and fall to the grate where they are completely burned. At the right of center will be seen the dark zone of low combustion which is evidently caused by the lack of air flow in the space between Zones 2 and 3. The secondary flame, which can not be seen here, arises from Zone 3 and flows parallel to the main flame well up into the throat where the two unite. This flame separation can be clearly seen in Fig. 5.

Figure 4 is taken through the large access door. Here the secondary flame is seen at the left and shows its characteristic curved outline. It will be noted that this flame is made up of a mass of burning particles of appreciable size, each with its characteristic plume of flame. Observation through color screens and motion pictures show that most of these particles are moving upwards at moderate velocities, meanwhile decreasing in size with surprising rapidity. Towards the center of the picture are larger particles in active combustion. These are either nearly stationary or falling slowly towards the grate. At the extreme right, close to the rear arch face, there is a downward stream of burning particles which have been projected against the rear arch and will fall to the grate and be burned out on the rear zones.

Figure 5 was taken through the throat observation door on the left side of the boiler and is, therefore, reversed in position to the other pictures, which were taken at the right side of the setting. The main flame at the right is curving up around the nose of the front arch and is moving at very high velocity. The dark zone before mentioned is evident near the center and the narrower band of secondary flame is seen at the left. The two flames have very nearly united at this point. The back side of the throat and the water wall are just out of the picture at the left. Between these and the secondary flame is a comparatively clear zone filled with many fine incandescent particles, probably fly ash, floating about. Practically no burning fuel particles can be distinguished at this height above the grate as the flames are very dense.

Figure 6 was taken through the rear end observation door. Here we are looking towards the front of the furnace and directly into the flame-sheet, which is too dense to permit a view of the advancing fuel bed on the other side. Slag formations on the side wall are dimly seen at the extreme right. The grate surface in the lower foreground is nearly bare and the eye can distinguish the outline of every grate clip. A few small flame points are seen in the foreground where some particles of carbon are burning out of the ash. The lumps showing on the grate are small bodies of slag, fallen from the walls or arches. Since installing the water wall, it is noted that the slag formations do not build up so rapidly or heavily. They are softer and break off naturally after a certain weight accumulates. Previously, at this rating, the formation was rapid, the sur-

face molten with almost continuous streams running down on to the grate.

Careful observations at the back end, during this run, showed no fire going over into the ash pit, the discharged ash being entirely black and more or less powdery in appearance.

It was found impossible, with the equipment at hand, to get satisfactory pictures through the front or No. 1 observation door on account of insufficient illumination in the front of the furnace. The volatiles burn with a nearly colorless flame and the wall temperatures are below incandescence, also the amount of light reflected from the main flame is small. An attempt to take moving pictures of the fuel bed at the cut-off point was also a failure for the same reason. The approximate shape of the fuel bed at the cut-off has, however, been indicated in some degree on the furnace cross section. The action here is peculiar, in that the 16 in. fuel bed practically disappears a foot or more in front of the apparent edge of the main flame. There is no visible movement of fuel across this space nor anywhere in front of the flame, the area appearing perfectly clear, yet the coal is reaching the base of the flame at the rate of 10,000 lb. per hr. It was hoped that a motion picture would help, in some degree, to explain this apparent phenomenon.

It might be expected that there would be a marked loss of unburned carbon through the stacks, as a considerable part of the ash passes out in this direction. It will be noted, however, that the upper furnace chamber is of such shape that the gas velocity is sharply reduced after leaving the throat, so that the heavier coal particles drop out of suspension and are returned to the flame by gravity and little unburned carbon escapes. Ash pit losses are likewise low, as the rear of the grate is nearly bare and a small quantity of air can be admitted under accurate control, to effectively burn out any remaining fuel.

The short fire is very stable and, once established on a given zone, requires only nominal attention. The furnace draft balance being maintained automatically, the control centers mainly in occasional adjustment of stoker speed to hold an average value of CO_2. Large increments of load are met by increasing the fan speeds and, if necessary, the stoker gate opening, to increase the depth of fuel bed.

Excepting only the item of increased furnace maintenance at the higher ratings, the short fire method of burning lignite has proved most satisfactory in every way. With the addition of suitably located water wall sections in the furnace, the maintenance problem is apparently solved.

Reconditioning Leather Belts

DEGREASING, RESPLICING, PULLEY ALINEMENT

BY J. N. SMITH*

FOR SOME TIME past, in many plants to keep machines running at minimum expense a process of "robbing Peter to pay Paul" has been common, belts being taken from idle equipment for use on active drives. When orders come to start production on shut-down machines, the belts may be missing and must be found, reconditioned and made ready for service. Even if left on a machine but having been idle for some time, a belt should be carefully inspected and, if necessary, reconditioned as to cleanness, splices and alinement of pulleys.

Belts that have become saturated with mineral oil should be soaked in gasoline or carbon tetrachloride for 24 hr., or longer if necessary. This will remove not only the mineral oil but also the natural oil that is necessary to lubricate the fibers, hence after cleaning the belt by scraping, it should be given a dressing of good belt lubricant. Scraping should be by a dull edged tool with rounded corners, as a sharp edge may injure the fibers. Dressing should be free from stickiness or it will not penetrate the fibers to give proper lubrication. Never permit lumps of belt dressing or of foreign matter such as dirt or chips to gather on belt or pulley surfaces.

Lap splices should be checked to make sure that they have not started to separate, especially at the tips. If a lap joint is to be remade, scrape off all the old cement; roughen the surfaces with coarse emery cloth, a rasp or wire brush before applying new cement.

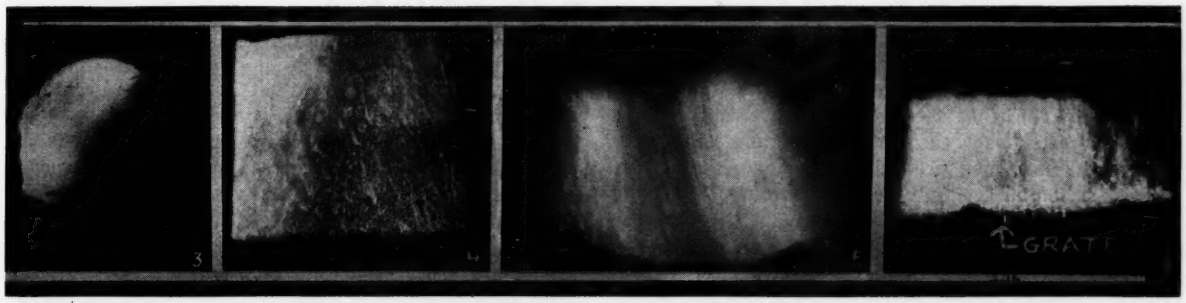
If a belt has been left under tension on an idle drive, it will no doubt be permanently stretched and should be shortened to give the desired tension. It is better to remove an idle belt from the pulleys until needed; also after shortening, a belt should not be put on until needed.

All fasteners should be gone over carefully and any that are worn or broken replaced, as a worn fastener may let go at any time and a broken one will cause the belt to run crooked, also will damage wood or composition pulleys.

Pulley alinement is important to belt life and transmission efficiency as well as to safety of workers, hence should be carefully checked and any misalinement corrected.

Many belts have been ruined by incompetent repairing. Application, maintenance and repair should be in the hands of a competent, experienced man.

*Engineering Dept., E. F. Houghton & Co.



FIGS. 3 TO 6. PHOTOGRAPHS TAKEN AT POINTS INDICATED ON FIG. 2 BY NUMERALS CORRESPONDING TO THE FIGURE NUMBERS

POWER PLANT ENGINEERING May 1933

Dissertation on Non-ferrous Metals Used for Power Plant Piping

Copper, Lead, Tin, Zinc, Aluminum, Nickel and Their Various Alloys Are Highly Valuable for Special Services in the Piping System.

By Henry C. Moffett.*

METALS used to manufacture materials for piping, other than iron, steel and alloys of steel, are principally copper, lead, tin, zinc, nickel and aluminum. Copper, tin and lead are employed alone, that is unalloyed, to manufacture pipe and fittings for various purposes, as are nickel and aluminum, although these last two are not as commonly used.

Non-ferrous alloys, in general practice, are in four groups; brasses, bronzes, copper-nickel alloys and nickel-copper alloys.

These metals and alloys are more expensive than iron and steel, but resist corrosion better, and therefore are better adapted for service in conditions where it is necessary to convey corrosive liquids, or where pipes must be buried in corrosive soils.

Extensive Uses for Copper Piping

Copper, next to iron, is the most widely used metal in piping practice. Its use ranges all the way from pure copper pipe and fittings to alloys having only a small percentage of copper. Pure copper is not used extensively on account of its low strength and high cost, except for plumbing and heating. A patented joint has recently been developed for copper pipe and fittings, utilizing capillary attraction to draw in the solder. This forms an annular lock, and it is claimed that the joint is stronger than the pipe. The manufacturers claim many advantages over the old sweated connections and wiped joints.

Copper pipe and tubing is seamless and drawn, and may be secured in standard iron pipe sizes, and extra heavy iron pipe sizes, as well as in special outside diameters and thicknesses for plumbing work. Extra long lengths of copper tubing for use in modern houses and buildings, may be had in coils. It is possible to cut the cost of such installations considerably by shortening water lines, due to the fact that such tubing is soft and can be bent around obstructions, or threaded through small spaces without fittings. Copper is ideal for water lines, especially when the water is hot, as it never rusts or corrodes on the inside.

Drawing copper into tubes improves the texture, makes it harder, more dense and stronger. It may be annealed readily by heat. Commercial copper is over 98 per cent pure and may be obtained in a purity of 99.88 per cent if desired.

Lead, in the form of pipe, has long been used in the plumbing trade. It also enters into many alloys, as it increases machineability.

Chemical lead has small percentages of copper, nickel and other impurities, which occur in the ore; other metals are added to it, so that it will resist acid corrosion. Some of these leads contain as high as 10 per cent of antimony, which greatly increases its hardness and tensile strength, and is less apt to be eaten away by weak acid solutions, such as are employed in chemical plants.

Lead lined pipe is used to some extent, and this combines the strength of steel pipe with the corrosion resisting properties of lead.

Lead pipe comes in calibers of ⅜ in. to 2 in., in reels of any desired length, while larger sizes, 2½ to 6 in. calibers in nominal lengths are offered. Lead pipe is manufactured in seven thicknesses, for a wide variety of purposes, but may be obtained in almost any thickness desired, on order.

Uses for Tin, Zinc, Aluminum and Nickel

Tin is manufactured into tubing in small sizes only. Tin-lined steel pipes, valves and fittings are obtainable for use in chemical works. Tin-lined pipe will outlast steel pipe many times, where corrosive liquids are handled, and therefore the higher cost is justified. Lined pipes of this kind are usually fabricated to exact measurement in the shop, as it is necessary to flange the lining thus preventing any of the steel casing from coming in contact with the corroding chemicals handled.

Zinc finds its greatest use in the alloys, especially with copper. Large quantities of zinc, however, form protective coatings on the outside of pipes, in the form of galvanizing. Galvanized steel pipe is used where pipes are exposed to warm humid air, and in many cases when such pipes are buried, to prevent corrosion on the outside.

Most zinc is impure, and the coating on the galvanized pipe may be quite high in iron. This impure zinc is more resistant to corrosion than zinc that contains no iron.

Aluminum may be drawn into seamless tubes, which are offered in nominal sizes from ⅛ in. to 4 in. Aluminum fittings may be die-cast, or molded, but the molded castings are likely to be porous.

Aluminum pipes should be insulated from all iron or other metallic pipes, to prevent galvanic action, if in contact with water.

Nickel, in the pure state, is rarely used in piping, except as a plating material. Numerous alloys contain the metal, some of which are used in great quantities, both for valve parts and complete fittings. Nickel alloy steels are commercially very important, and nickel alloy cast irons are becoming continually more important, since nickel increases the strength of these metals without introducing any disadvantageous features.

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Nickel and copper in varying proportions, and with lesser amount of other metals, form a wide range of alloys, some of which will be considered later.

Malleable nickel, deoxidized by the use of magnesium, may be rolled, forged and pierced. Manganese is added, to assist in purging and alloying other small percentages of impurities that are always present, such as copper, iron, sulphur and silicon.

Pierced nickel tubes are offered the trade, but only a small amount of it is used in piping.

Brass Most Popular Alloy for Fittings

Brass is essentially an alloy of copper and zinc; other metals are at times added to give desired properties. Copper or zinc alone is soft and weak, whereas in alloys in proportions up to 45 per cent of zinc, the resulting metal is strong and ductile. Beyond this percentage of zinc, the metal is brittle.

An alloy is an intimate mixture of metals in solid condition. The resulting mixture is crystalline in structure, and a study of the structure, by etching and magnification, often reveals what has taken place. Crystal size has some relation to strength, especially in alloys of non-ferrous metals, the smaller the crystals, as a rule, the greater the strength.

Alloys may be strengthened by cold or hot working or drawing. This breaks up the large crystals into smaller ones. Cold worked alloys should be carefully annealed to remove internal stresses, and thus prevent intercrystalline weaknesses from developing.

Red brass, also known as Ounce metal, or Hydraulic bronze, has a chemical composition approximately as follows: Copper, 85 per cent; Zinc, 5 per cent; Tin, 5 per cent; Lead, 5 per cent. Of the five or six hundred non-ferrous alloys used commercially, red brass finds the widest use for pipe fittings and valve parts. This alloy is low in zinc, as brasses go, but high in tin and lead, and is listed as a bronze in the U. S. Government Master Specifications. According to this authority, red brass of the above specification should have the following physical characteristics:

Tensile strength, 27,000 lb. per sq. in.

Elongation in 2 in., 15 per cent.

Red brass fittings for piping work, both standard and extra heavy, screwed or flanged, are obtainable from reputable manufacturers in either rough, polished, tinned or nickel plated form. The range of sizes vary with different producers, but in general, the screwed fittings range from ⅛ in. to 6 in. in nominal sizes, while the flanged fittings in standard weights, may be had from 2 in. to 6 in. The extra heavy varieties vary from 1 in. to 6 in.

Red brass, because of its high tin content, approaches a bronze. The lead makes it machine much better. The zinc is added for economy. This brass is superior to yellow or commercial brass in all respects, and finds a wide use in plumbing work, for which purpose many special fittings, cast in this metal, may be found listed and illustrated in several trade catalogs.

Government specifications list two grades of yellow brass, naval and commercial.

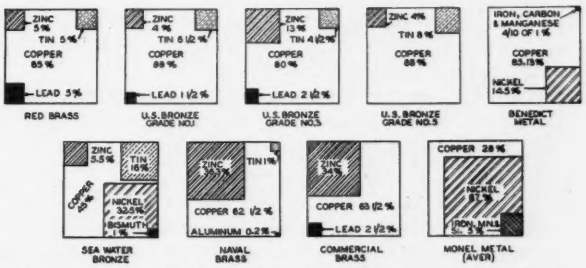
Naval brass has the following chemical composition desired: Copper, 62.5 per cent; Zinc, 36.3 per cent; Tin, 1.0 per cent; Aluminum, 0.2 per cent. When properly cast this should show physical characteristics approximately as follows:

Tensile strength, 30,000 lb. per sq. in.

Elongation in 2 in., 15 per cent.

Naval brass is used for corrosion resisting castings where strength requirements are not so important, such as handwheels for valves, hand rail fittings and small valves.

Commercial brass, or common yellow brass, is approximately two-thirds copper and one-third zinc, with about 2 to 3 per cent of lead. The tensile strength is much lower than naval or red brass, and therefore it is not recommended for castings that are to be subjected



SOME REPRESENTATIVE NON-FERROUS ALLOYS USED IN PIPING PRACTICE

to water or air pressure. Because of its lead content, commercial brass machines better than naval brass.

Brass should never be employed for piping work if the temperature of the liquid or gas conveyed exceeds 400 deg. F., especially if the pressures are in the neighborhood of those specified for the rated fittings.

A typical steam metal, often referred to as a brass, but which is really a bronze, because of the tin content, has a composition which is: Copper, 86 per cent; Zinc, 3 per cent; Tin, 8 per cent; Lead, 3 per cent. This metal has a tensile strength of only about 31,000 lb. per sq. in. at normal room temperature, which decreases to around 21,000 lb. per sq. in. at 450 deg. F.

Application of Bronze in Piping

Bronze is usually higher in copper and tin than brass, with the zinc content much lower, and therefore greater tensile strengths are to be expected. Some varieties of bronze contain large percentages of nickel; some small quantities of aluminum, phosphorus and other metals. Each of these metals gives the particular bronze to which it is added some definite properties, some of which are extremely important.

A high grade steam or valve bronze, with fair tensile strength and great elongation, is known as U. S. Grade No. 1 and has the following approximate composition: Copper, 88 per cent; Tin, 6.5 per cent; Zinc, 4.0 per cent; Lead, 1.5 per cent. The zinc may vary from 1.5 per cent to 5 per cent in this alloy without great harm. The physical properties are about as follows:

Tensile strength, 32,000 lb. per sq. in.

Elongation in 2 in., 17 per cent.

Another bronze, widely used for standard and extra heavy water, air and gas fittings, is made up of these proportions: Copper, 80 per cent; Tin, 4.5 per cent; Zinc, 13.0 per cent; Lead, 2.5 per cent. This grade, known as U. S. Grade No. 3, has an approximate tensile strength of 28,000 lb. per sq. in.

An excellent steam bronze is known as U. S. Grade No. 5. It is used for special pipe fittings, valves and bushings when higher strength and better corrosion re-

sistance are desired. Its composition is: Copper, 88 per cent; Tin, 8 per cent; Zinc, 4 per cent. This bronze has a tensile strength of about 40,000 lb. per sq. in., and an elongation in 2 in. of 20 per cent. Low percentages of phosphorus and lead are permitted in this alloy.

Phosphor bronze is approximately 96 per cent copper and the remainder tin. Phosphorus is added to the melt to deoxidize the tin, thereby adding greatly to the strength of the alloy. Only a very small amount of the phosphorus remains in the bronze.

This bronze can be tempered and used as springs for valve regulating devices. Its high strength, about 65,000 lb. per sq. in., in tension, makes it valuable in small sections, and its high acid resistance makes its use important in corrosive surroundings.

Leaded phosphor bronze has about one per cent of lead added, which lowers its strength, but increases its usefulness, especially its resistance to sea water corrosion.

A good bronze, containing nickel, which resists sea water corrosion, has approximate contents as follows: Copper, 45.0 per cent; Nickel, 32.5 per cent; Zinc, 5.5 per cent; Tin, 16.0 per cent; Bismuth, 1.0 per cent. This alloy is sometimes called "Sea Water Bronze."

Copper-Nickel Alloys

Copper and nickel when alloyed in varied proportions, remain malleable and ductile in the entire series. The greatest hardness is found in those alloys containing around 50 per cent of each metal.

Relatively small amounts of nickel make copper-nickel alloys white or silver-like in color, and increase their toughness. In sheet form, some of these alloys have tensile strengths as high as 90,000 lb. per sq. in., and elongations in 2 in. of only 4 per cent.

Alloys of copper and nickel, containing nickel in the range of 14 per cent to 16 per cent are used for condenser tubes and feedwater heater tubes. One of the best known is Benedict Metal, which has a typical analysis, such as: Copper, 85.13 per cent; Iron, 0.25 per cent; Manganese, 0.12 per cent; Carbon, 0.003 per cent; Nickel, 14.50 per cent. This alloy, after cold rolling, has a tensile strength around 47,000 lb. per sq. in., a yield point of 22,500 lb. per sq. in. and an elongation in 2 in. of about 35 per cent. This metal resists corrosion very well.

Nickel-Copper Alloys

These alloys, containing over 50 per cent of nickel, find a wide use in piping work, and several brands are on the market. They are highly resistant to erosion and corrosion, and great quantities are therefore used in high pressure work for valve seats, discs and stems.

Probably the best known alloy is monel metal. This is a natural alloy made from a matte by roasting and reducing with charcoal. The average composition of monel metal is: Nickel, 67 per cent; Copper, 28 per cent; Iron, manganese and silicon, 5 per cent. At times, a small percentage of carbon and sulphur may be present.

Monel, even in cast forms, may have great strengths, up to 80,000 lb. per sq. in. and in hard sheets, 100,000 to 120,000 lb. per sq. in., which compares favorably with some high-tensile steels.

Cast monel has a dendrictic structure, which can be seen as fern-like figures in magnified etched sections. This may be one reason for its toughness and strength. One of the happy coincidences in its use is the fact that monel has practically the same thermal expansivity as that of steel, and that therefore, seats, discs and valve parts screwed into steel valve bodies, are quite apt to remain tight.

Another alloy of this general character is known as modified monel metal, or M-M-M. In this alloy, about 10 per cent of tin displaces around 7 per cent of nickel and 3 per cent of copper, the silicon, iron and manganese content remaining about the same. This alloy is successfully used in many chemical industries for fittings and valves and can withstand superheated steam at high pressures and temperatures.

Another alloy, valuable for packing rings, and used in superheated steam installations, has the following approximate composition: Lead, 80 per cent; Antimony, 20 per cent. It is claimed that this metal will produce a tight joint and will show very little wear.

For saturated steam, a cheaper alloy may be used, such as: Lead, 84 per cent; Tin, 8 per cent; Antimony, 8 per cent.

Many other alloys are on the market, some of which are useful in special process work, and new ones are introduced from time to time. Some, containing high percentages of magnesium, are finding new uses every year.

Court Ruling On Power Development

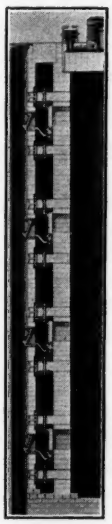
By A. P. Connor, Washington Correspondent

POWER conferred on the President to reorganize and rearrange the governmental departmental activities is of vast consequence, and among the steps already taken by him is to place the Federal Power Commission where it will coördinate with other features of the control of the natural resources of the United States. The definite plan will be more fully disclosed when given a trial and completely proven satisfactory.

The important case of the Appalachian Electric Power Co. against the members of the Federal Power Commission has been given a decision in the District Court of the United States for the Western District of Virginia. The purpose of this suit was to question the right of the Commission to take jurisdiction of the company as it was not on the waters proper of a navigable river, although it was on one of the tributaries of the Kanawha river. Further the company proposed to build a dam which would be 150 mi. away from any so-called navigable rivers. The Court decided that the Federal Power Commission did have jurisdiction in view of the fact that the project could withhold sufficient water from the navigable waters to seriously affect its navigability, especially in times of drought. The company, however, is not completely barred from building its project if it complies with the requirements desired by the Chief of Engineers, which are so designed as to insure navigability of the Kanawha river at all times.

This decision is important in that the ruling gives the Commission authority to control the erection of water projects on small streams if such projects could store enough water to affect the stages of the navigable waters further down the river, although the project itself might be hundreds of miles away from navigation.

Power Utilization



INSULATION
for Boiler Rooms and Piping Systems

Furnace Walls, Economizers and Air Preheaters because of the High Temperatures to Which They Are Subjected Require Careful Insulation to Prevent Excessive Heat Loss.

EVERY SQUARE FOOT of the heated surface of boiler room equipment is teeming with heat units, released from confinement in fuel by the magic of combustion and eager to escape the prosaic career of steam making or air and water heating by taking wing into the free atmosphere. Not all of these can be turned back from truancy to their appointed tasks but many can be and it becomes a question of economy how far it will pay to go in placing barriers of insulation to reduce the numbers of the escaping horde.

Temperature and area of the surfaces are the factors which determine the rapidity of escape we call radiation, while the thickness and resistance to heat flow of the insulation used determine the effectiveness of the barrier in turning back the stampede.

Furnace Walls

Evidently the higher temperature surfaces such as furnace walls, economizers and air heaters will require more insulation than water and steam piping. In the case of furnace walls, most brick walls are not insulated; water-cooled walls which are common in central stations but not in industrial plants, serve the same purpose as insulation in rounding up errant heat. For a bare, fire-brick wall 22½ in. thick, the radiation will be some 770 B.t.u. per hour per square foot of area. If operation is 10 hr. a day for 300 da. a year, the yearly loss is $3000 \times 770 = 2{,}310{,}000$ B.t.u. or the equivalent of 0.0825 t. of coal at 14,000 B.t.u. per lb. At $3.50 a ton this is some 30 cents a year loss per square foot of surface. For a furnace with four sides of 300 sq. ft. each, this becomes $360 a year.

By installing 3 in. of insulation at a cost of 95 cents a sq. ft., the radiation can be reduced to 330 B.t.u. per sq. ft. per hr., a saving of some 57 per cent or reduction of 17 cents in the cost of heat loss, which is a yearly return of 17.9 per cent on the cost of insulation. This return increases directly in proportion to the hours a year that the plant is operated.

For water walls, a common form of insusulation consists of 1½ in. of tile, 2 in. of insulating block and 2 in. of 85 per cent magnesia, surrounded by a sheet metal casing. For such a wall, the radiation is about 68.5 B.t.u. per sq. ft. per hr., as against 770 B.t.u. for uninsulated brick wall. Coal cost for radiation on the basis above used would be $0.026 per sq. ft. for a 3000-hr. year. The bare brick wall loss is, therefore, eleven times as great as that from the water wall and 2.2 times that for insulated brick.

Other forms of insulation sometimes used for water walls, outside of the 1½ in. of tile, are 2½ in. of rock wool, compressed to 2 in. thick, or 5 in. of insulating cement. For the former, heat loss is 117 B.t.u.; for the latter, 81 B.t.u. per sq. ft. per hr. Yearly coal costs per sq. ft. are $0.0491 and $0.03055 respectively. Tabulating the results given and using bare brick wall as a comparison for savings we have the following:

Saving by Insulating Furnace Walls

Construction of Insulation	Cost Per Sq. Ft.	Yr. Saving in Coal Cost	% Return on Cost
3-in. insulating brick	$0.95	$0.157	16.55
Two layers—2-in. brick and steel casing	1.112	0.264	23.70
2½ in. rock wool	0.801	0.241	30.00
5-in. insulating cement	1.565	0.259	16.55

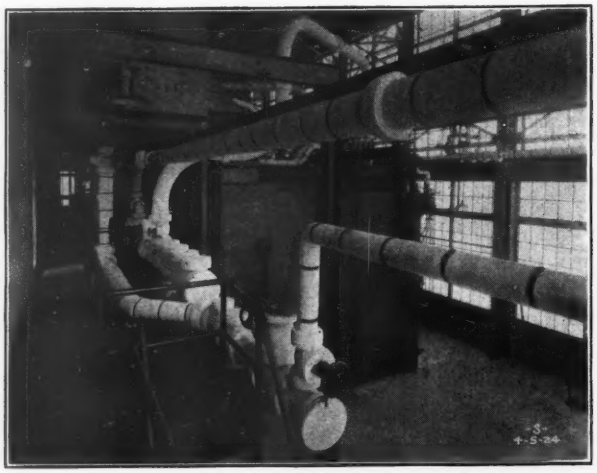
By such tabulation of any proposed method of insulation, comparison can readily be made of the return on the investment required for various forms.

In modern settings, so much of the front, side and rear walls are subject to nearly furnace temperatures that they would be insulated as for furnace walls. On

top, the upper sides of drums may usually be covered with 4 in. of 85 per cent magnesia to advantage and the top of the setting with 3 in. of the same, covering this with a layer of brick or a coat of cement to give a wearing surface.

For the uptake or the flue leading to the economizer, which carries gases at 450 to 800 deg. F., a covering of 1½ in. of hi-temperature cement plus 3 in. of 85 per cent magnesia and an outer coating of ½ in. of asbestos cement will be satisfactory and likely to be a good investment.

On economizers, it is often desirable to use block of a thickness the same as the height of flanges on the



HEAT ECONOMY REQUIRES COMPLETE INSULATION OF STEAM PIPE AND FLANGES

casing so as to have a smooth outer surface over which to place wire mesh. The block is held in place by sticking to the casing with a cement and by the wire mesh, the latter also serving as a base for a ½-in. finish coat of hard cement. Evidently, the higher the gas temperature in the economizer, the thicker will be insulation that can give best economy but, as thicker insulation costs more, the return on the investment required will be less as thickness increases. The point of best economy will be found where additional investment can bring greater return for some other use than for thicker insulation. For gas temperature of 500 deg. F., 2 in. of 85 per cent magnesia; for 600 to 800 deg., 2 in. of hi-temperature; and for 900 deg., 3 in. of the same, in any case with ½ in. of finish of asbestos or hard cement, will usually be satisfactory. The radiation, with gas at 750 deg. and air at 80 deg., through 2 in. of hi-temperature insulation and ½ in. cement will be some 175 B.t.u. per sq. ft. per hr.; with 1½ in. hi-temperature, 3 in. of 85 per cent magnesia and ½ in. cement will be 70 B.t.u. As an indication of relative return, the first ½ in. of insulation will give some 3000 per cent a year on the investment; 1 in. will give 780 per cent; 2 in., 175 per cent; 3 in., 75 per cent; 4 in., 42 per cent and 5 in., 26 per cent. As between the 2 in. of hi-temperature insulation and the combination of 1½ in. hi-temperature with 3 in. of 85 per cent magnesia, the return on extra cost of the added 2½-in. will be some 30 per cent. Likewise for gas at 650 deg. and air at 80 deg., the return on the difference in cost between 2 in. of hi-temperature, allowing 160 B.t.u. loss per sq. ft. per hr. and 1½ in. hi-temperature plus 2½ in. of 85 per cent magnesia, allowing 60 B.t.u. loss per sq. ft. per hr. will be some 47 per cent.

Air Heater and Ducts

In all cases considered, an outer coating of ½ in. of cement is to be provided. With this, for heaters delivering air at 382 deg. and atmosphere at 80 deg., 2 in. of 85 per cent magnesia will allow radiation of 62 B.t.u. per sq. ft. per hr. while 3 in. of 85 per cent magnesia will reduce this to 43 B.t.u., giving a return of 29 per cent on the cost of the added 1 in. of insulation. Not only this, but a smaller heater can be used to give the desired air temperature.

For hot air ducts, which carry air at 350 deg., 2 in. of insulation will permit loss of 54.5 B.t.u. per sq. ft. per hr. while 3 in. will reduce this to 38 B.t.u., the added 1 in. costing 12 cents a sq. ft. and giving 25 per cent return on that extra cost. Ducts and flues carrying hot gases or air, where workmen might be burned by contact but heat saving is of minor consequence, will be sufficiently safeguarded by a 1-in. covering of 85 per cent magnesia.

Piping

Thickness of insulation or steam piping to give best economy will depend on temperature of the steam carried and the size of the pipe, the most usual arrangements being as follows:

Kind and Thickness of Pipe Insulation for Best Economy

Steam Temp.	Nominal Pipe Size: To 2½ in. Diam.		2½-10 in. Diam.		10 in. and over Diam.	
Deg. F.	Kind	Thick.	Kind	Thick.	Kind	Thick.
171-212	85% mag., Std.		85% mag., Std.		85% mag., Std.	
275-340	85% mag., 1½ in.		85% mag., 2 in.		85% mag., 2 in.	
400-500	85% mag., 2 in.		85% mag., dbl. Std.		85% mag., Dbl.	1½ in.
700-900	hi-temp., 2 in.		hi-temp., 2½-6 in. +85% mag., 2 in.		hi-temp., 6 in. +85% mag., 2 in.	or more

While flanges are often left bare either for convenience in checking for leaks or because it's a bother to cover them, they are a cause of considerable heat loss. For instance, a 6-in. extra-heavy flange joint, with steam at 300 deg. F. causes the same loss as 1.8 ft. of pipe and the cost of providing removable insulating covers will be repaid by about 1 yr. savings in heat loss.

Standard pipe covering is most convenient, made in halves with 8-oz. canvas jacket. This can be sewed on, then sized and painted, making it durable and easy to keep clean. Where segment insulating blocks are used, they can be covered with a coat of hard asbestos cement, then with a sewed jacket and a coat of paint.

Cold water runs should be covered to prevent the mess due to sweating and drip. Thickness of insulation required for this purpose varies with the humidity of the surrounding air and the temperature difference between air and the water in the pipe. For 70 per cent humidity, up to 60 deg. temperature difference, 1 in. of insulation is desirable; for 70 per cent humidity and 70 deg. temperature difference or for 80 deg. humidity and 50 deg. difference, 1½ in. thickness; for 70 to 80 per cent humidity with temperature difference 60 to 70 deg., also for 80 to 85 per cent humidity with 50 deg., 2 in. thickness; for 80 per cent humidity and above with 60 deg., use 2½ in. and with 70 deg. or over temperature difference, use 3 in.

Dangerous Light Lifting

By W. F. Schaphorst

BELIEVE IT or not, more engineers and firemen, injure themselves due to "light lifting" than due to "heavy lifting." In other words, light work causes injury more frequently than heavy work.

Why is this? Because, when something comparatively light, such as a piston, cylinder head, gate valve, or anything humanly liftable is to be moved, the engineer says to himself: "Shucks, I can lift that and put it in place in a jiffy. Nothing to it at all. I won't bother with a tackle or truck."

Result? Likely a rupture or strained back. Probably a slip, fall, crushed foot, or broken bone.

Take for example the heavy engine frame shown in Fig. 1 which is being unloaded from a flat car. It is a

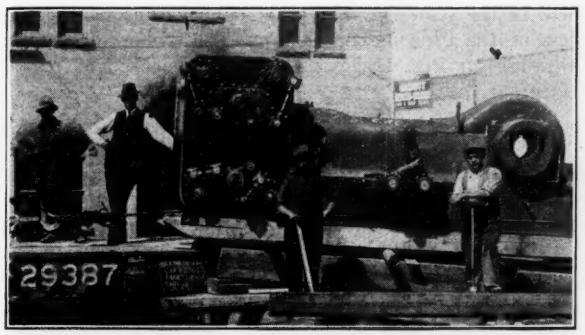


FIG. 1. MOVING HEAVY ENGINE FRAME

safe bet that nobody was injured in handling that engine at *any* time because of its great bulk and weight. Workmen cautiously use block and tackle, crow bars and rollers. Direct lifting is not attempted because too obviously it is impossible.

In a room full of heavy power plant equipment, nobody will be hurt lifting that machinery because the place is equipped with a crane and with a chain hoist. Using four, five or more men to lift an object that one man alone cannot lift, is poor practice in this machine age and is expensive. I have seen track laborers throwing railroad rails onto cars. Twenty or so men will string along a rail, elevate the rail over their heads and heave it onto the car. It is slow, dangerous and at $3 a day, it is easy to see that the cost of labor is $60 a day, which would quickly pay for an absolutely safe mechanical method.

An excellent type of all purpose lifter for use in and around the power plant is shown in Fig. 2. It lifts, lowers, carries, loads and unloads, all with safety and economy. Only a few years ago ice cans were pulled by hand. Today it is common to find a mechanical puller to pull not only one can but several at once.

Machinery does not bleed. When a machine is smashed there is no workman's compensation bill to meet. Machinery is feelingless, tireless and not subject to human frailties. That is why machinery should be made to do as much work as possible. Take this actual typical instance: A special cast valve body was delivered on a hand truck to a power plant. The casting was heavy but could be lifted by hand. The assistant engineer decided to lift it without the use of a chain hoist and proceeded to "save time." But the casting slipped and in slipping a sharp burred edge cut one of his hands severely. Although first aid was administered, a serious case of blood poisoning developed so that healing the wound proved lengthy and expensive. The total cost of "saving time" by trying to lift the casting without mechanical means amounted to $1200.

One important point as to chain hoists is the weight of the hoist itself. What I have written should make it clear that the hoist itself should be so light that a man can easily lift, carry and hang it, without the possibility of harm by straining himself in handling the hoist. It

FIG. 2. ALL PURPOSE MOTOR CRANE

would be silly to go after a hoist weighing 100 lb. to lift a weight of only 100 lb., wouldn't it? And it is equally silly to strain yourself by lifting a heavy hoist which you are using for the very purpose of avoiding strains. Be consistent. If you must use a heavy hoist for lifting an exceedingly heavy weight, the logical thing is to use a light hoist for putting the heavy hoist in place. In other words, use machinery for doing all lifting which is likely to prove harmful in any way if done by direct muscular force.

Mechanical and animal energy of 110,000,000 hp.-hr. a day are used by American farmers during the 100 busiest days of cultivation, planting and harvesting. If human labor of all able-bodied inhabitants were substituted, food supply would be so reduced that the entire nation would be constantly bordering on starvation. In countries depending on hand cultivation such a condition actually exists today. In such circumstances there is no chance for fear of a "depression". Any disaster results in famine and starvation. Leonard J. Fletcher before Am. Soc. Agr. Engrs.

When a short circuit occurs somewhere on a line supplied by a generator, an excessive current flows into the circuit. This current is limited by the total impedance of the circuit and that impedance consists of the impedances of the armature circuit, leads, and lines out to the short. Assuming that normal voltage is maintained by the generator under a short circuit condition, the short circuit current will be $I_s = E_g \div X_t$, where I_s is the short circuit current in amperes; E_g the generator voltage and X_t, the reactance out to the short.

POWER PLANT ENGINEERING May 1933

Checking Up On Refrigeration Plant Operation

IN ORDER TO HAVE THE PLANT PERFORM AT ITS HIGHEST EFFICIENCY IT IS NECESSARY TO KNOW WHAT EACH PIECE OF EQUIPMENT IS DOING. BY RAY B. WOLF

REFRIGERATION is produced in numerous power plants throughout the country in hotels, hospitals, food industries and manufacturing plants. The production of this refrigeration is often a small part of the total energy used and little attention is paid to the horsepower cost per ton developed although in many cases substantial savings can be made by an understanding of the effects under different operating conditions.

Power requirements of a refrigerating machine vary over a large range as the suction and discharge pressures change. The horsepower calculation is a difficult one for an operating man with limited technical training, as it involves lengthy formulas and a use of the tables of the properties of the refrigerant. The calculation is further complicated by the changing value of the volumetric efficiency of the compressor under the changing conditions of suction and discharge pressures.

To assist the plant engineer to operate his plant economically, the charts shown were made for determining the horsepower requirement per ton of refrigeration

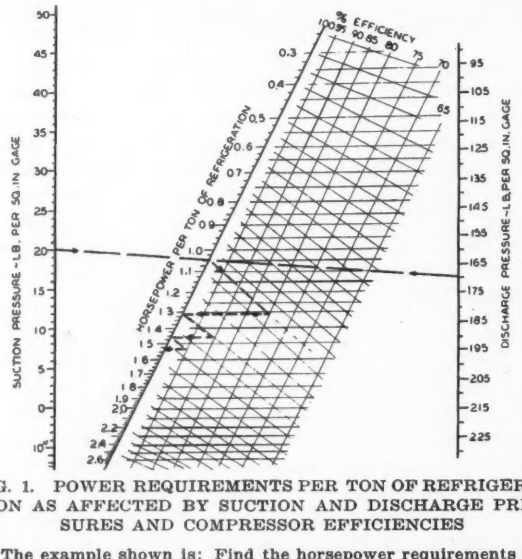


FIG. 1. POWER REQUIREMENTS PER TON OF REFRIGERATION AS AFFECTED BY SUCTION AND DISCHARGE PRESSURES AND COMPRESSOR EFFICIENCIES

The example shown is: Find the horsepower requirements per ton of refrigeration for a compressor operating at 20 lb. suction and 170 lb. discharge gage pressures with a volumetric efficiency of 80 per cent, mechanical efficiency of 90 per cent and a drive efficiency of 95 per cent. Following the dotted line the theoretical horsepower is found to be 1.05; the actual horsepower allowing for volumetric efficiency, 1.31; the horsepower allowing for the mechanical efficiency of the compressor, 1.46 and the horsepower allowing for the efficiency of the drive, 1.53. Note that the same final result can be obtained by multiplying the three efficiencies together, 80 × 90 × 95 to give an overall efficiency of 68.5 per cent as indicated by the light dotted line.

under a wide range of conditions and with a minimum of calculation. The charts were developed for reciprocating compressors using ammonia, as this refrigerant is the most widely used. With its aid one can readily determine the horsepower requirements per ton of refrigeration between the pressures of 15 in. vacuum and 50 lb. gage on the suction line or low side and 90 lb. to 230 lb. gage on the discharge line or high side. The intersecting point of the diagonal scale with a line connecting the suction pressure on the left with the discharge pressure on the right gives the theoretical indicated horsepower per ton of refrigeration.

This theoretical indicated horsepower is the actual horsepower required to perform the necessary work on the ammonia gas in raising its pressure from the low to the high or condensing side and its determination will be the same for the same set of conditions, regardless of the type of compressor. The example followed through on Fig. 1 shows clearly the method of procedure.

EFFECT OF VOLUMETRIC EFFICIENCY

Volumetric efficiency of a compressor differs with the pressure changes and the change is greater when the suction pressure varies than a like amount of change in discharge pressure. This is readily apparent in the curves shown in the small chart. These curves are for a medium speed vertical single acting compressor and a slow speed double acting compressor, both with poppet type valves. These curves are representative of values of compressors of this class. A 10 lb. increase in suction pressure at 20 lb. suction pressure and 150 lb. discharge pressure will increase the volumetric efficiency 2.25 per cent while a 10 lb. decrease in discharge pressure at 20 lb. suction and 150 lb. discharge will only increase the volumetric efficiency by 0.75 per cent.

It should be noted that the absolute pressures are required to determine the compression ratio which means that 14.7 must be added to the gage pressures to get the proper values. In the examples stated, mentioned in the paragraph above, we have (150 + 14.7) ÷ (20 + 14.7) or a compression ratio of 3.7 and (140 + 14.7) ÷ (20 + 14.7) or a ratio of 4.45. Volumetric efficiency values can be easily found by following from the bottom line of Fig. 2 vertically to the intersection with the top curve (assuming a vertical single acting machine is being considered), and then reading the value on the left-hand scale. We find 87.25 per cent for 3.7, 85.75 per cent for 4.45 and 85 per cent for 4.75. This indicates that suction pressures are a greater factor in power requirements than discharge pressures and this will be shown in detail further on.

Suction pressure should be carried as high as possible consistent with the type of evaporator used. For the same compression ratio the vertical single acting machine is more efficient volumetrically than the horizontal double acting machine due in large part to the closer clearances possible in the vertical machine. The mechanical efficiency of a compressor will depend on its type, its state of repair and its speed, while horizontal types of compressors are somewhat lower in efficiency than vertical types due to greater amount of

parts and of rubbing surfaces and the slower speed. The mechanical efficiency of the prime mover and drive will depend on its type and application, it may be an electric motor, a steam engine or a gas or oil engine and the connection to the load may be direct or belted.

Mechanical efficiencies do not vary much under normal operating conditions and once determined may be regarded as constant for a long period of time. A study of the chart shows that with a constant suction pressure of 20 lb. gage, a 10 lb. increase in head pressure from 95 lb. to 105 lb. will increase the horsepower per ton over 11 per cent and that an increase of 10 lb. from 215 lb. to 225 lb. the horsepower per ton increases the capacity over 3 per cent. This would show that the greatest saving takes place at the lower range of the discharge pressure. The effect of head pressure on horsepower can be further investigated by taking extreme pressure ranges. At 0 lb. gage suction pressure and 225 lb. gage discharge pressure the horsepower per ton is nearly

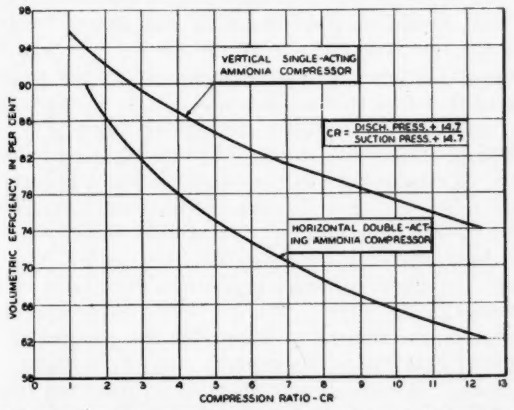

VERTICAL SINGLE-ACTING AMMONIA COMPRESSOR
CR = DISCH. PRESS. + 14.7 / SUCTION PRESS. + 14.7
HORIZONTAL DOUBLE-ACTING AMMONIA COMPRESSOR
VOLUMETRIC EFFICIENCY IN PER CENT
COMPRESSION RATIO - CR

FIG. 2. THE VOLUMETRIC EFFICIENCY OF A COMPRESSOR DECREASES AS THE COMPRESSION RATIO INCREASES

69 per cent more than at 0 lb. gage and 95 lb. gage pressure. With 50 lb. gage pressure on the suction side the horsepower per ton increases 192 per cent when the discharge pressure increases from 95 lb. to 225 lb. gage. This increase in horsepower per ton is a strong argument for clean condenser surfaces and a periodic checking of water flow to keep the condenser pressure where it belongs.

The above calculations are for the theoretical indicated horsepower requirements and are mentioned to show the difference that is possible. Of course, a pressure range of from 0 lb. gage to 225 lb. gage in a single compressor would result in extremely high gas temperatures at the discharge and such conditions would not be countenanced in a well managed plant.

It has been shown that the volumetric efficiency of a compressor drops off very decidedly when the compression ratio increases due to increasing the head pressure or lowering the back pressure or both. As an example we find that theoretical indicated horsepower per ton at 20 lb. suction gage pressure increases 104 per cent when the discharge pressure is raised from 95 lb. to 225 lb. and under these same conditions the volumetric efficiency of a vertical single acting compressor has dropped from 98 per cent to 81.5 per cent or 7.5 per cent in efficiency and the actual indicated horsepower of the compressor has increased 120 per cent.

Swimming Pool Water Sterilization

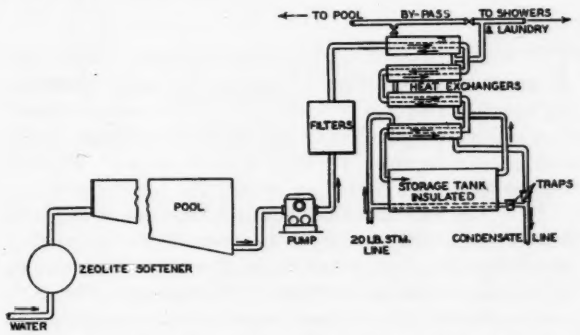
FRANK H. BROOME

AT FIRST glance, it might appear that cost of sterilization of such water by steam would be prohibitive. But by using heat exchangers and adequate insulation, the method is quite economical.

Capacity of the equipment depends of course upon the size of the pool, the number of people using it, the number of hours it is used daily, the amount of water used for showers and laundry and the cost of the water.

Chemicals may be used with the heat system although they should not be necessary.

It will be noted from the accompanying diagram that filtered sterile water from the pool is used in the show-



LAYOUT OF EQUIPMENT FOR SWIMMING POOL STERILIZATION

ers and probably in the laundry, after being partially cooled from the sterilization temperature. By using a number of heat exchanger sections, water of different temperatures may be tapped off between various sections. To make up for this loss of water, fresh water is added to the pool after passing through a zeolite softener, as soft water should be used to prevent scale formation on the tubes of the heat exchangers.

Water from the pool is pumped through the usual filters and hair and lint catchers into the heat exchangers in which it is heated to at least 240 deg. F., being kept under a back pressure of 15 to 20 lb. One exchanger is supplied with steam, the other sections being heated by the outgoing water. From the exchangers the water flows into a storage tank which has a capacity fifteen times the per minute rating of the circulating pump, so that the water is held at a temperature above 240 deg. for at least fifteen minutes. This tank must be suitably insulated and equipped with a steam coil.

Leaving the storage tank, water passes through the heat exchangers, giving up its heat to the incoming water. By arranging the piping so as to bypass certain of the heat exchangers, it is possible to regulate the temperature of the pool water.

If a high-temperature boiler is used, the steam for the exchanger and coil in the tank should pass through a regulating valve maintaining a pressure of 20 lb. and protected on the low-pressure side by a safety valve to prevent the generation of steam in the steam-heated exchanger and tank.

The only heat used for sterilization, in addition to the heat ordinarily required for water heating, is that required to meet the radiation losses of the equipment.

POWER PLANT ENGINEERING May 1933

Ten Million Volts Direct Current!*

Describing the New Electrostatic High Voltage Generator being constructed at Massachusetts Institute of Technology. This apparatus will provide a higher direct current potential than ever attained before and will be used in the Physicist's Battle to storm the stronghold of the Atom's Energy.

TEN MILLION VOLTS, direct current! The mere mention of the fact is enough to cause electrical engineers to gasp, so why should not the announcement of a generator which will produce this voltage excite interest and curiosity? How does it work? What is it to be used for?

For several months now engineers have been greatly interested in the construction of the ten million volt electrostatic generator at the Round Hill laboratory of the Massachusetts Institute of Technology. For aside from its value as a new and powerful instrument in researches relating to atomic structure and atomic disintegration, this machine is of interest in that it incorporates entirely new principles of design and that it is the first unit ever built to deliver a continuous current at so high a voltage.

Despite its startling voltage there is little or no mystery about this machine and when we interviewed Dr. Van de Graaff who developed it, in his laboratory at M. I. T. he was only too glad to explain not only its action, but also the history of its development. And he was extremely modest about his part in the work, insisting that President Karl Compton was largely responsible for the carrying out of the project. It was Dr. Compton's interest and encouragement in the project he said that had enabled him and Dr. L. C. Van Atta to bring the work to such a spectacular stage.

*Prepared from an interview with Dr. Robert J. Van de Graaff of the Massachusetts Institute of Technology.

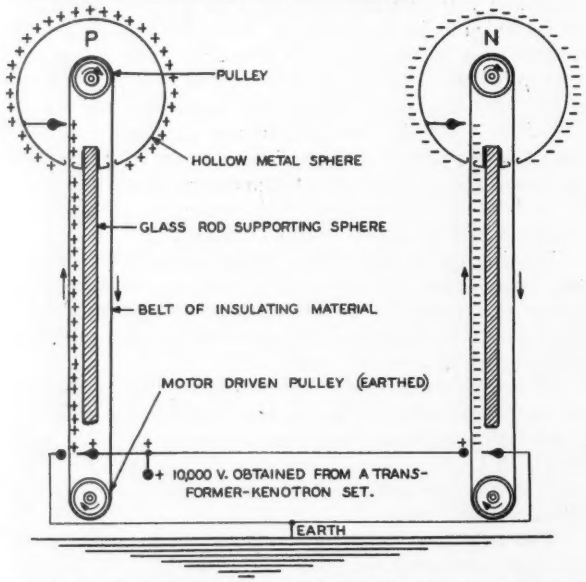


FIG. 1. THE GENERATOR AS ORIGINALLY CONCEIVED

The generator was developed primarily to provide a source of steady high voltage direct current for use in experiments having to do with the disintegration of the atom. Surge generators of five million volts and over have been available for some time, but as Dr. Van de Graaff explained, all these generators have been of the electromagnetic type. While these electromagnetic generators are admirably suited for the production of large currents within the general range of voltages corresponding to extranuclear phenomena, there are inherent difficulties in the extension of such devices into the range of extremely high voltages demanded by nuclear physics.

It was because of these difficulties inherent in the electromagnetic principle, Dr. Van de Graaff said, that he went back to electrostatic principles and developed the electrostatic generator. This proved to be not only extremely simple, but remarkably effective.

In this machine, "electricity" at low voltage is "sprayed" onto a rapidly moving belt which carries it upward into a spherical terminal on which it is deposited. This is all that there is to it. As the belt carries more and more electricity to the sphere, the charge and potential rise to a point at which further increase is limited by the breakdown of the surrounding insulation.

To explain this more clearly, suppose we outline the successive ideas which led Van de Graaff to develop this type of unit. To begin with, maximum simplicity was sought. The simplest terminal assembly appeared to be a sphere mounted on an insulating column. Since the sphere must be charged and since the process should be continuous, the charge carrier should approach the sphere, enter it, and after depositing its charge inside, should return parallel to its path of approach. These considerations immediately suggested the action of a belt—long used for the transmission of mechanical power.

In Dr. Van de Graaff's own words, therefore—"the logic of the situation pointed directly to a generator consisting of a hollow spherical conducting terminal sup-

ported on an insulating column, a moving belt to carry electric charges to the sphere, a device for depositing the charge onto the belt in a region of low potential remote from the sphere and a device for removing this charge from the belt inside the sphere and transferring it to the sphere."

These ideas were incorporated in an experimental set-up and a refinement added whereby a charge of the opposite sign was carried by the belt on its return journey, thus doubling the current output. A second refinement consisted of a self-exciting charging device whereby the entire generator could be made to operate independently of any external source of electricity.

The details of this generator are shown diagrammatically in the accompanying illustration. In Fig. 1 "P" and "N" are the positive and negative terminals mounted on insulating supports with belts of silk or other flexible insulating material mounted on pulleys as shown. The charge is sprayed onto each belt as it passes between a metallic surface and one or more sharp points so adjusted as to maintain a brush discharge from the

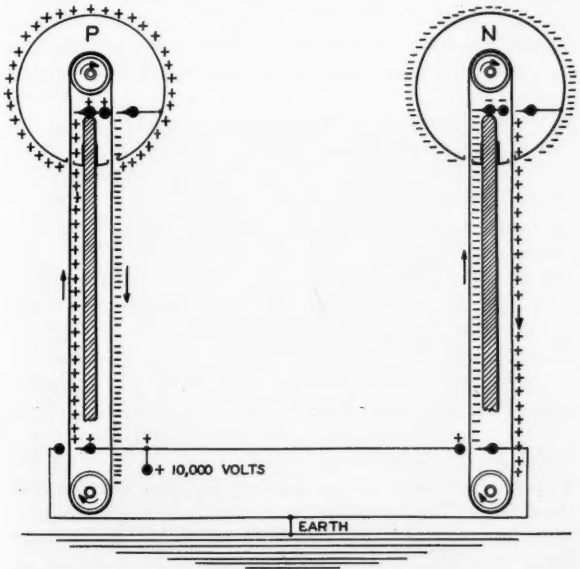


FIG. 2. THE GENERATOR ARRANGED FOR CARRYING ELECTRICITY OF OPPOSITE SIGN AWAY FROM THE ELECTRODES

points towards the surface. When connected as shown one point sprays positive and the other negative electricity onto its adjacent belt. Within each sphere the charge is drawn off the belt by adjacent sharp points and transferred to spheres. Since the interior of the sphere is similar to the interior of Faraday's "Ice Pail" the charge passes readily between the charged belt and the sphere irrespective of the potential of the sphere.

As a consequence of this, the voltage attainable is limited only by the corona breakdown at the surface of the spheres. This, as is well known, depends in a known manner upon their size, smoothness and other factors. The larger the size of the sphere the higher the attainable voltage.

To prove the correctness of these ideas, a small model was constructed in 1929. This was more or less hastily improvised from tin cans and a few yards of bolting silk, but it operated satisfactorily and produced a potential of 80,000 v. In 1931 a larger unit was built, using

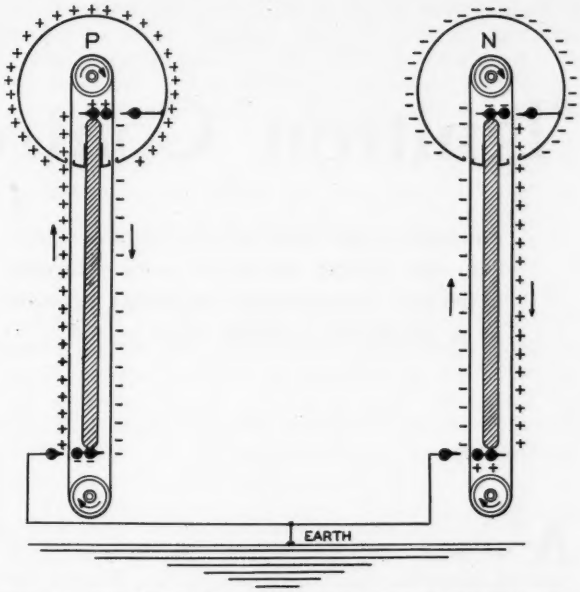


FIG. 3. THE UNIT ARRANGED FOR "SELF" EXCITATION

24-in. spherical electrodes mounted on 7 ft. upright Pyrex rods and charged by two 2-in. silk ribbons. This unit which was charged by a 10,000 v. kenotron rectifier set, delivered a current of about 25 microamperes at 1,500,000 v. Costing only $100 this generator developed approximately twice the voltage of any direct current source of which we have knowledge.

The success attained by these first models led to the large unit now being constructed at Round Hill on the estate of Col. E. H. R. Green. This unit has spherical terminals made of aluminum alloy, 15 ft. in diameter and mounted on cylindrical Textolite columns, 24 ft. high and 6 ft. in diameter. It is charged by belts made of a special paper. On the basis of theory and experience with the experimental models, this unit will have a power output of around 20 kw. though this can be greatly increased by adding more belts.

The diagram in Fig. 1 shows the principles of the generator as first conceived. In Fig. 2 it is shown with the first refinement added, that is, with the device for removing the charge of opposite sign. In Fig. 3, the unit is shown to be entirely self exciting—the kenotron rectifier set has been eliminated.

Boston Smoke Abatement Control

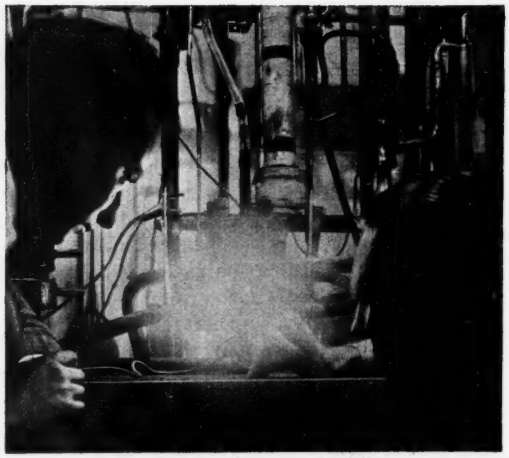
By H. S. Knowlton

Controversy over this matter has been ended by passage of an act that keeps smoke abatement as an activity of the Massachusetts Department of Public Utilities. The question arose as a matter of saving $50,000 a year by abolishing inspection but the 22-yr. record of the service and sentiment in favor of reducing air pollution won, though a saving was attempted by doing away with inspection of new plant designs and confining supervision to emission of smoke from stacks. Use of soft coal has increased in the Boston area during the depression and alertness as to apartment and office building performance has been necessary. Large public utility plants with efficient combustion equipment give little trouble.

POWER PLANT ENGINEERING May 1933

"Ignitron" Control

An entirely new method of control for mercury arc devices in which a tiny current applied to a pencil lead can control currents in an electric arc a million times greater.



AMONG the many interesting papers presented at the recent winter meeting of the American Institute of Electrical Engineers, one by Dr. Slepian and L. R. Ludwig of the Westinghouse Research Laboratories on a new method of controlling an arc[1] in mercury arc devices provoked considerable interest. This method makes use of an entirely new principle and was shown to be more positive and many times faster in action than methods now in use. The arc can be started 60 times a second at any point on the voltage wave and since this method does not require the use of a grid to be protected from heating, large currents are controlled just as easily as small ones.

The secret of this control, to which the name "Ignitron" has been applied, lies in a high resistance rod of lead or carborundum, partly immersed in the mercury pool. This rod, when energized, starts the arc. For a ⅛-in. resistor rod dipping ¼ in. below the surface of the mercury, tests showed the minimum voltage for starting the arc to be about 130 v. A sudden application of 250 v. started the arc in less than 5 microseconds.

Applications of this new method of starting will be obvious to anybody familiar with grid controlled gas tubes. In such tubes, until now, an arc cathode has been maintained by a separately heated thermonic

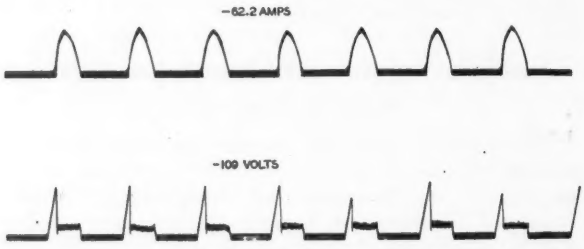


FIG. 1. OSCILLOGRAM SHOWING INSTANTANEOUS VOLTAGE AND CURRENT OF IGNITING ELECTRODE

cathode or a "keep alive" arc. The starting of an arc to the main anode is then controlled by a grid. Now the permanent arc cathode and control by the grid may be eliminated and the starting of the arc to the main anode effected and controlled entirely by the new starter.

[1]A new method for initiating an arc.

This development is an outgrowth of Dr. Slepian's studies of the electric arc, which previously resulted in the "Deion" principle applied to circuit breakers, lightning arresters and fuses. Electric arc phenomenon is extremely complex and it is only in recent years that a satisfactory explanation has been arrived at. A brief account of some of the theories of arc phenomena will not be out of place here.

The origin or seat of the arc's great capacity to carry large current at low voltage resides definitely in the cathode, where with a drop of only 10 or 20 v. thousands of amperes per cm² are carried. The problem of the formation of the arc, therefore, reduces itself to a study of the cathode and the circumstances which cause an arc cathode (as differentiated from a "glow" cathode, which cannot carry much current) to form.

Since gases are normally insulating, the maintaining of a discharge requires the presence of ionizing agents. In the gas itself, ionization by collision with molecules or electrons accelerated by the electric field seems to be adequate to account for the observed conductivities. At the cathode a space charge sheath exists and the whole current must be carried either by electrons liberated from the cathode or by positive ions from the gas. If the current is small, this theory is adequate and is probably the mechanism of the Townsend or dark discharge and the "glow" discharge, but for an arc cathode to occur some other explanation is necessary, since ionization by collision is insufficient to account for the high currents. A new ionization agent must be found.

One theory is that thermionic emission at the cathode is the new ionizing agent and while this is satisfactory where the cathode is at high temperature, it does not satisfy conditions where the cathodes are too cold for thermionic emission. Another theory is that in the arc a very high positive space charge density adjacent to the cathode produces so intense a field that electrons are actually pulled out of the cathodes. Still another theory is that very intense thermal ionization in the gas layer adjacent to the cathode supplies positive ions to carry the current to the cathode. Here again, because of the large heat loss from this hot gas layer to the cold cathode, a considerable current density is necessary.

The problem, therefore, which confronted the investigators was to provide a great density of electrons at

the cathode in an extremely short time interval so as to initiate the formation of a true arc between two electrodes already under a certain difference of potential. A number of methods for doing this already existed but most of these were subject to definite limitations which made the development of a new method desirable. The existing methods were as follows: (1) The thermionic cathode principle used in all hot filament gas filled tubes. (2) Separation of contacts which causes destructive arcing at switch and circuit breaker contacts. (3) Blowing of fuses, closely related to separation of contact principle. (4) Spontaneous transition from glow to arc. (5) The electric spark. (6) The high frequency discharge. (7) Striking an arc from an already existing arc.

In their first attempts, Slepian and Ludwig devised an arc cathode starter which operated upon the separation of contact principle but was free from the inertia difficulties of ordinary separating contacts. A small section of pointed tungsten rod was placed in a mercury arc tube so that it dipped slightly to a depth of about one millimeter below the mercury surface. On sending current through the rod, the cathode of an arc was promptly started at the rod-mercury junction and this starting could be repeated 60 times per sec.

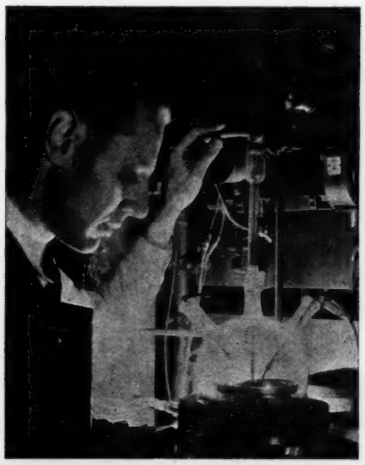


FIG. 2. LEON R. LUDWIG WITH THE "IGNITRON" CONTROL

Experiments with this type of starter led to the discovery that a rod of relatively high resistivity partly immersed in mercury had extraordinary properties with respect to the initiation of arc cathodes on the mercury surfaces. The first observations were made on a carborundum crystal. It was found that a current of ten amperes flowing through the crystal would start an arc cathode, the action having little to do with the degree of immersion of the crystal.

This extraordinary property for starting arc cathodes was found to belong generally to materials of considerable resistivity. Later on, it was found that the mercury pool was not an essential element in the operation of the starter, as regular operation was obtained with a starter rod partly buried in solidified tin.

In the operation of this starter, the time required for the formation of the arc cathode after the application of the necessary voltage was found to be extremely short—a sudden application of 250 v. would start the arc within less than 5 microseconds.

The insensitivity of the new starter to the degree of immersion in the mercury indicated that its operation did not depend upon the actual breaking of contact with the mercury. When operated just below the voltage required for regular operation, frequent tiny sparks would be observed at the mercury-rod junction. This suggested that the seat of the phenomenon resided at the mercury-rod junction, and also suggested that the operation might take place in two stages; first, the starting of a tiny arc cathode (the sparks observed above) which would call for a very high electric gradient or large concentrations of energy to affect a thermal explosion similar to what occurs at the last contact point of separating contacts, and second, the building up of the small current flowing from this tiny arc cathode to an arc current sufficient to short circuit the rod to the holder or another anode. Both of these requirements seem to call for the existence of an electric gradient down the rod to the mercury junction.

These considerations suggest that with respect to voltage and energy concentration conditions at the starter rod mercury junction must be similar to those occurring at the last contact point of separating contacts, and electrostatic theory shows this to be the case.

This method of control apparently is extremely reliable and the device is not subject to wear. A number of units have been in operation at the Westinghouse research laboratories, igniting arcs sixty times per second 24 hr. a day for over 9 mo. Although each of these units has started more than 1,400,000,000 arcs they show no sign of wear.

Rectifier and Reactor Combinations Produce Interesting Non-Linear Circuits

RECENT EXPERIMENTS with various combinations of rectifiers, reactances and resistances have brought to light new ideas in electric circuits, some of which are not only novel but give promise of considerable commercial application. It seems that by setting up combinations of rectifiers and reactors, non-linear circuits result which can be made to produce a wide variety of effects with no moving parts or electric contacts. At the General Electric Co. laboratory where these circuits were developed, application has already been made for the control of the large General Electric Co. electric sign on the roof of the research laboratory. This sign is 150 ft. long, towers 70 ft. above the roof and contains 1378 25-watt incandescent lamps. It consists of the G. E. monogram in a circle and the words General Electric spelled out in capital letters below the monogram. Previously the sign was entirely illuminated all the time but now with the new control the sequence of operation is as follows: When the current is cut in there is a moment of darkness. Then 400 lamps in the circle of the monogram are lighted gradually over a period of about 3 sec. The 300 lamps in the script "G.E." within the circle are then lighted gradually over another 3 sec., the circle remaining bright. With the complete monogram illuminated, the 700 lamps of the two words beneath then

burst into view, a half second being given for them to assure full brightness. After a few moments of complete brightness, the hundreds of lamps in the complete sign are dimmed uniformly over a half-second period. A moment of darkness and the cycle is automatically repeated.

This control, as has been pointed out, is obtained by combinations of saturable-core reactors, copper oxide rectifiers and resistances built up into a circuit similar

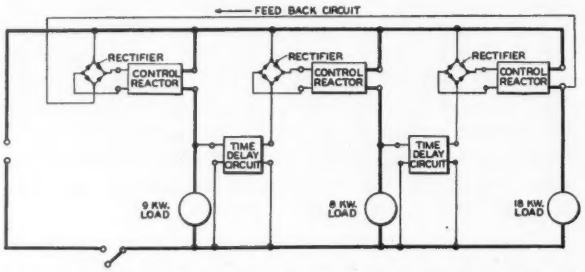


FIG. 1. SIMPLIFIED DIAGRAM OF THE NEW CONTROL AS APPLIED TO THE GENERAL ELECTRIC SIGN

to that shown in Fig. 1. The saturable-core reactors used are essentially iron core inductances so arranged that the inductance may be changed by saturation of the core material with direct current. One watt in the direct current winding is sufficient to control 100 watts in the alternating current circuit.

The method of control is from 85 to 95 per cent efficient and practically unity power factor operation is provided. An important property of the saturable-core reactor is a time delay factor that is required for substantially full-load voltage to appear after the direct current is applied. This time delay, which may be varied in duration by use of a variety of circuits, provides the sequence operation which is independent of the thermal characteristics of the incandescent lamps. Feedback circuits are employed to cause sequences to repeat, or commutate. The load reactors are also the control reactors; auxiliary control means are not required. The

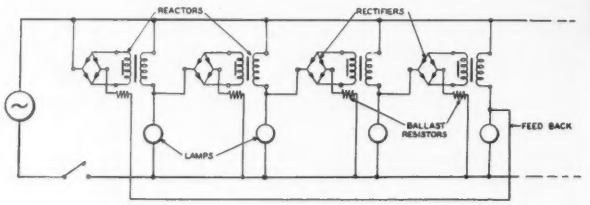


FIG. 2. FEED BACK MAKES LAMP FLASHING CIRCUIT REPETITIVE

circuits are entirely free from radio interference, and are silent in operation.

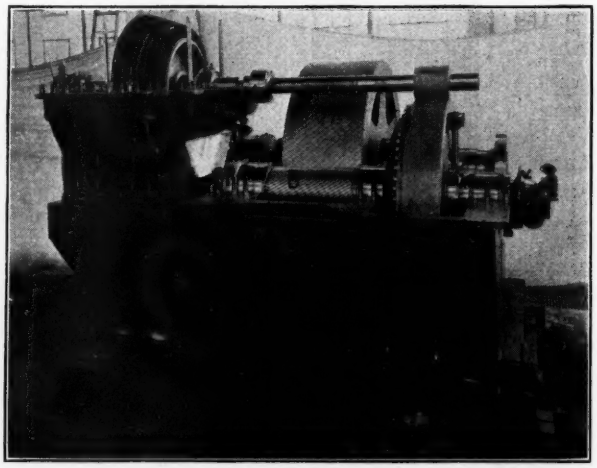
In another such circuit, shown in Fig. 2, a chain of lamps is caused to flash in sequence. In this arrangement, each reactor acts as a variable impedance, dimming out its lamp until the voltage across the preceding lamp has risen as it is flashed on. The rectifier across that preceding lamp then gets enough more current to saturate the core of the succeeding reactor, reduce its impedance and flash the lamp in series with it. Under the action of the feed back from the last lamp in the chain, the first lamp finally begins to dim and the action becomes periodic and progressive.

Among the applications for such types of non-linear circuits there have been suggested, in addition to sign flashers, the control of illuminated fountains, airport border-light flashing, architectural and colorama lighting control, and similar uses. Still other types of non-linear circuits have been suggested for traffic and airport beacons, electric clocks, induction heating, electric music and high-frequency sirens.

Power from Exhaust Steam

TO INCREASE POWER and speed in order to meet a mail contract calling for 13 knots an hour, S.S. Point Aucha of the Gulf Pacific Mail Line Ltd. was recently fitted with a De Laval exhaust turbine, installed in space formerly occupied by the thrust bearing, that being moved 10 ft. outward. The turbine is mounted on the casing of the double reduction gear which reduces from the turbine speed of 3250 r.p.m. to propeller speed of 95 r.p.m.

As shown, the reduction includes two sets of single helical gears, with a hydraulic coupling contained in the casing of the first reduction gear, A, to prevent



ARRANGEMENT OF EXHAUST TURBINE AND REDUCTION GEARING

transmission shock and permit disconnecting the turbine without stopping the engine. Driven half of the coupling is mounted on the shaft of the low-speed pinion, B. Some slip is involved but the loss is not over 3 per cent of the power developed by the turbine, which is offset by reliability and convenience in operation.

Except when maneuvering or going astern, exhaust steam from the original reciprocating engine goes to the turbine. For those two conditions, engine exhaust goes direct to the condenser, connection being controlled by a change valve on top of the turbine casing. This valve is operated automatically by an oil relay actuated by the reverse shaft of the engine. The engine develops 2600 i.hp. to which the turbine adds 1075 shaft hp. without increasing steam consumption. This has increased speed from 11.5 knots to an average of 14 knots and has noticeably steadied operation.

New Castle Completes New Diesel Station

RECENTLY New Castle, Indiana, completed extensive changes in its municipal light and water plant in order to handle its growing street lighting and pumping loads. Diesel engine driven generators and motor driven pumps have been installed and the old boiler room and remaining steam driven equipment have been retired to standby service.

Two generating units have been installed. The smaller is a 500 hp., 4 cyl. engine, direct connected to a 345 kw., 0.8 p.f. generator and a 10 kw. exciter; the larger a 750 hp., 6 cyl. engine direct connected to a 518 kw., 0.8 p.f. generator and a 15 kw. exciter. Both de La Vergne engines are 240 r.p.m., 17½ by 24 in., 4 cycle solid injection machines rated at a full load M.E.P. of 71.2 lb. per sq. in. The generator and exciter were supplied by the Electric Mach. Mfg. Co. The first are 2300 v., 3 ph., 60 cycle units, the latter 125 v. d.c. compound wound. Both engines are equipped with American air filters and de La Vergne air silencers on the intakes and de La Vergne mufflers on the exhaust, with an Alnor indicating pyrometer to show the exhaust temperature from each cylinder. The switchboard and instruments were supplied by Westinghouse.

At present 30-32 deg. Be. Kentucky oil is being used, preliminary operation showing approximately 12 kw. hr. per gal. The fuel is unloaded by a Viking pump to an 18,000 gal. above ground steel storage tank and transferred before use to an underground tank. From here another Viking pump located in basement transfers it to day tanks in the engine room.

Raw water available for jacket cooling runs about 21 gr. per gal. of magnesium carbonate so a closed cooling system using water treated by a Permutit zeolite softener was installed. This soft water is cooled in Griscom-Russell heat exchangers in the base of a Prichard cooling tower. Soft water is circulated by two pumps, one, for the smaller engine, 200 g.p.m. 70 ft. head unit, driven by a 7½ hp. motor, the other, for the larger engine, a 350 g.p.m. 70 ft. head unit driven by a 10 hp. motor. These pumps are cross connected so either unit can be used on either engine if necessary. Raw water is circulated over the tower by either of two pumps, one rated at 225 g.p.m. 50 ft. head, driven by a 5 hp. motor and the other rated at 400 g.p.m. 50 ft. head and driven by a 10 hp. motor. All four pumps were supplied by Goulds and are driven by 1750 r.p.m. General Electric motors.

In summer it is expected that the normal temperature leaving the jackets will be 135 deg. F., allowing a 14 deg. F. rise. A Fisher thermostatic valve in the fuel line automatically shuts the unit down if the jacket water temperature reaches 165 deg. F. The units are also shut down automatically if the lubricating oil pressure drops below 3 lb.

VIEW OF THE LARGE ENGINE WITH THE WATER WORKS PUMPS IN THE PIT IN THE FOREGROUND. THE END OF THE SECOND ENGINE IS JUST VISIBLE AT THE LEFT OF THE PHOTOGRAPH AND THE INSTRUMENT BOARD WITH THE MULTIPOINT PYROMETER APPEARS JUST OVER THE END OF THE GENERATOR

Starting air is furnished by two stage, 4 by 2½ by 2¾ in., 250 lb. Ingersoll-Rand compressors, one driven by a 3 hp., 1750 r.p.m. General Electric motor, the other by a Wisconsin gasoline engine. In addition there is a Hydroil purifier with 3 and 6 kw. heating elements and de La Vergne duplex oil filters. Auxiliaries are all driven by 220 v. motors and are installed in a basement formed by a ledge on the engine foundation.

Water System

Water was formerly pumped from wells by air lifts and these were replaced by three Cook deepwell pumps driven by 20 hp., 220 v. United States motors. These pumps deliver to three storage reservoirs from which three new booster pumps take their suction. These latter are 3,000,000 g.p.d. Allis Chalmers horizontal centrifugals driven by 2200 v., 1750 r.p.m. slip ring motors. The three pumps are arranged in parallel end to end on a loop suction line so piped and valved that any pump can be isolated for repair without disturbing the other two or can take its suction from either of the three storage reservoirs. Crane suction valves are installed on their side so as to eliminate an air pocket in the bonnet of the valve.

Plain leather faced check valves are used in each discharge line; normally both the discharge and suction valves are left open and by means of the variable speed control the changeover from one pump to another can be made without disturbance or water hammer so that it is impossible to determine when the check valve seats.

At present the average pumping rate is about 2,500,000 g.p.d. with a peak of about 5,000,000 g.p.d. This with the street lighting runs about 175 kw. in the winter and, because of the greater pumping load, about 400 kw. in the summer.

The station was designed and built by the city. Fred Taylor is consulting engineer, Chas. Scholl superintendent of the pumping station and Nelson Howard is chief engineer.

POWER PLANT ENGINEERING May 1933

PUMP STORAGE *Compensates for Power Fluctuations in Two Different Hydraulic Development Areas*

By
Rene Leonhardt

Among the water power developments in northern Germany being developed at the present time one of the most interesting is the Schluchsee project now in course of construction. The fact that this project is under construction is a matter of interest in itself, for in recent times because of the acuteness of the economic crisis few projects are being developed. In other words, there must be a very good reason for the construction of this project, otherwise it would not have been attempted at this time. And such is the case.

This project is situated in the southern part of the Black Forest and utilizes water from the Feldberg district where the precipitation is very high. It is in the German state of Baden. The water power resources of Baden are about 3 billion kw.hr., made up of the water power of the Rhine, of the Black Forest rivers, of the Neckar and of the Main. Upper Baden derives its supply from a number of power stations on the upper Rhine. These stations, however, are located mainly between Lake Constance and Basle and owing to the heavy fluctuations in water level cannot supply a constant output. So a scheme was decided upon which provided for the erection of a large storage installation for the purpose of compensating for these fluctuations.

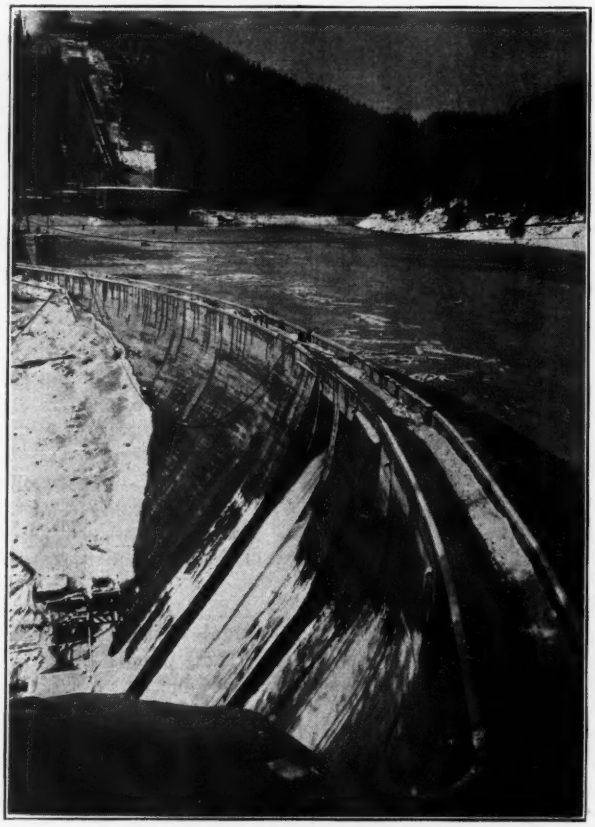


Fig. 1. Dam of the Schwarza Lake with storage reservoir. Hausern Power Station and substation in the background.

In September, 1928, therefore, the Schluchseewerk A. G. was formed and preliminary operations begun. The task of carrying out the work was entrusted to a large number of important German engineering firms under the direction of the firm of Messrs. Lahmeyer A. G.

In summer time there is a great increase in the flow of the Rhine and the greater part of this surplus water cannot be utilized. In winter, on the other hand, the level of the water is very low. In the case of the rivers of the Black Forest, conditions are just reversed; in winter time the flow amounts to 2/3 of the total annual flow, while in the middle of the summer only a limited quantity of water is available. In view of this, the best solution appeared to be to use the water power of the Black Forest for the erection of power stations with storage facilities which would supplement the power stations on the Rhine, the latter being utilized to deal with the basic load.

The Schluchsee installation thus fulfills two different functions in this connection. On the one hand it compensates the fluctuations in power supplied by the Rhine and on the other it utilizes the surplus energy from the Rhine for pumping water into the Schluchsee storage reservoir. It provides as a result of the natural difference in time of the high water period, for a uniform basic load which is nearly independent of the fluctuations in level of the Rhine.

The installation is for a total output of 290,000 kw.hr. Use is made of the total head of 1960 ft. between Schluchsee and the Rhine which is to be utilized in three steps, corresponding to the three stages provided for in the program of construction. The total capacity of

the storage reservoir will represent 130,000,000 kw.hr.

A diagram of the Schluchsee development is shown in Fig. 2. The reservoir, as can be seen, is at an elevation of 3078 ft. Water is led from the Schluchsee through a tunnel under pressure 3.7 miles long to the surge chamber above the Haeusern power station. The tunnel begins 52 ft. below the present water level opposite Schluchsee town and is deep in the interior of the mountain.

The Haeusern power station is equipped with 4 units each of which can develop a maximum output of 4900 hp. Each unit consists of a motor-generator rigidly coupled to a Francis turbine arranged so that it can also be connected to a pump for storage work. This is accomplished by means of an hydraulic mechanical Föttinger-Escher-Wyss coupling. The turbines are designed for a speed of 333.3 r.p.m. The output of the generators is 32,000 kv.a. with an overload capacity up to 36,000 kv.a. The pump which is of the two stage type is capable of delivering 2200 g.p.s. against a head of 622 ft.

Schwarza Lake which is situated directly below the Haeusern power station collects the water as it leaves

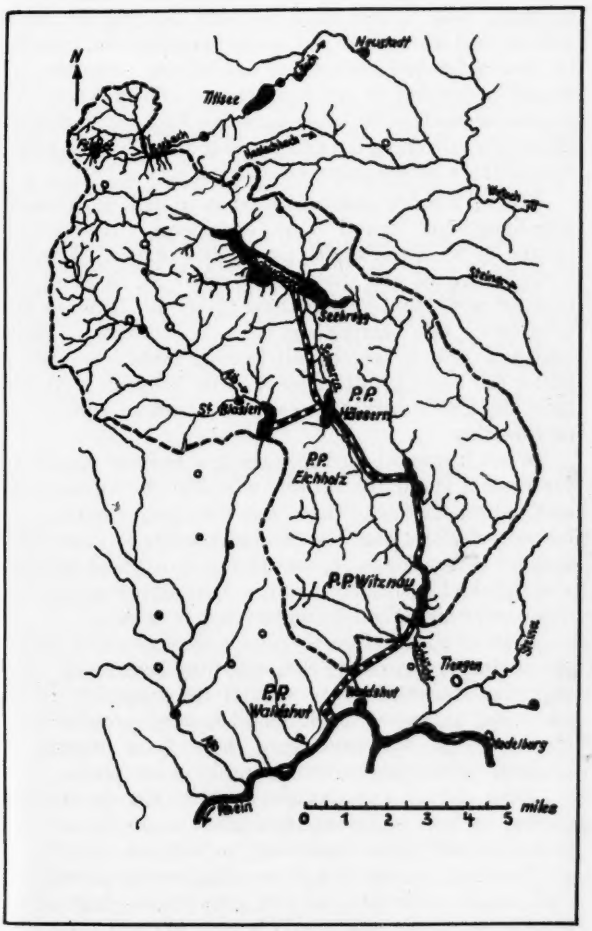


FIG. 2. MAP SHOWING THE POSITION OF THE SCHLUCHSEE DEVELOPMENT

the power station, and this water is used for the next step of the power development for which a head of 920 feet is available. The Schwarza valley dam is in plan an arched dam with a radius of 460 ft. The length along the crest is 482 ft. and the width 12 ft. while the thickness of the dam at the base at the level of the valley is 131 ft.

The second storage step of the project is not yet fully utilized. A temporary installation (Eichholz) has been erected to which water is led through a tunnel 1.7 miles long starting a little higher up than the dam. The water is utilized under a head of 420 ft. by two turbine units, each of 19,000 kv.a. capacity. This plant however, is temporary and will be taken out of service later on. The storage step down to the Witznau power station has not been proceeded with, nor has the last part down to the Waldshut power station.

The most important storage reservoir of the whole scheme is the Schluchsee which has been closed off by a dam 108 ft. high and 1640 ft. further down than the former outlet of the lake. This dam raises the level of the lake by 95 ft.

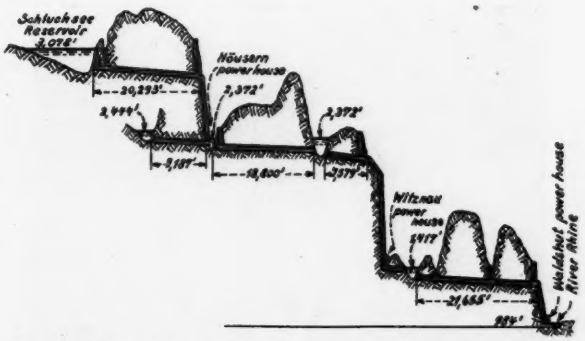


FIG. 3. ELEVATION OF THE SCHLUCHSEE PUMPED STORAGE HYDROELECTRIC DEVELOPMENT WHICH INCLUDES THREE POWER HOUSES AND A TOTAL HEAD OF ABOUT 2000 FT.

As mentioned before, only the first part of the program of construction has been completed and the Eichholz power plant is merely a temporary installation which is to disappear once the Witznau power station is erected.

This project is interesting because it is the first instance where two different power development areas have the same storage installations which serve not only for dealing with the daily fluctuations in load but also for storing energy to be used for compensation of fluctuations throughout the year.

In conclusion, the author wishes to state that this article was written in close cooperation with Messrs. Dyckerhoff and Widmann and Messrs. Siemens Bau-Union to whom the author is indebted for illustrations and who have constructed the sections of the Schluchseewerk described in the article.

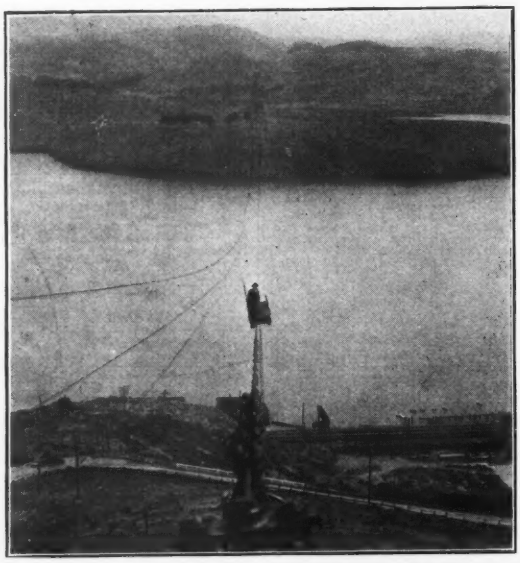
STORAGE BATTERIES are being used extensively in power plants and industrial service on various types of duty, requiring anywhere from a fraction of an ampere to currents of 80,000 amp. for 10-min. intervals. On some large city power systems such as in Chicago and New York, storage batteries installed have capacities sufficient to carry a major portion of the business load for from 10-min. to one-half and three-quarters of an hour.

Readers' Conference

Perilous Aerial Task Requires Steady Nerves

HIGH ABOVE Carquinez Straits a few miles north of San Francisco, so high above the heads of passengers on passing steamships, that they appear to be slender threads, are the 110,000-v. transmission cables which connect the Vaca-Dixon substation in Solano County with the Claremont substation in Oakland.

These cables, each seven-eighths of an inch in diameter and made of steel are strung between two massive towers, the span is 4400 ft. from north to south shore, and at their lowest point the cables are 216 ft. above the water.



POWER CABLES MUST BE PRESERVED—AND HOW.

To prevent deterioration it is necessary to remove periodically the soot and carbon deposited on these cables by smoke from passing steamers and to paint them with a coat of red lead and another of black.

This task, calling for iron-bound nerves, a cool head, patience and immunity to dizziness and air-sickness, is the daily routine of D. C. Irvine of Berkeley, California, who accomplishes the hazardous task in a small cage suspended from the particular cable on which he is working.

San Francisco, Cal. GILSON WILLETS.

Vibration in Turbines

SOME TIME AGO (page 810, December, 1932) you had an article on vibration engineering which was of particular interest to me because of a recent experience of my own.

We have a 1000-kv.a., 3-ph., 480 v., horizontal, separately excited turbo-generator with a normal speed of 3600 r.p.m. The unit has three main bearings and the alternator is coupled to the turbine by a rigid coupling close to the middle bearing which is on the turbine side of the coupling. The turbine which is of the impulse type takes saturated steam at 200 lb. ga. and exhausts at 29+ in. vacuum.

This unit had not been run for about 12 yr. because of dangerous vibration. It had had many experts try to balance it and had been run in all sorts of positions, such as swinging free on a crane and one end bolted down and the other end swinging free on a crane. It was wedged in many places, but the vibration continued. Many theories were advanced as to the cause; the steam end was out of balance; that the field was out of balance; there was a loose connection in the field winding; the shaft was sprung; there was too much clearance; there was not sufficient clearance; or the foundation was bad.

Vibration seemed to be all centered in the alternator outboard bearing, but experts would not concede that anything was wrong with the end bearing. I often believe engineers to be too prone to attribute troubles to too farfetched theoretical conditions, therefore we doggedly decided to concentrate our efforts where the trouble seemed to be located and to find out definitely if trouble existed in the end bearing and, if so, to eliminate it there before going elsewhere.

We put a screw jack under about an inch of the shaft over-hang and found that considerable lost-motion existed between the shaft and the end bracket. Further analysis proved the shaft about 0.007 in. loose in the bearing and the bearing about 0.005 in. loose in the housing. A new bearing was made with 0.0015 in. clearance and 0.006 in. automobile bearing shims were placed under the bearing to tighten it in its housing. The turbine was run slowly for nearly a month to run in the new bearing.

When it was believed that the new bearing was ready for normal speed the turbine was brought up to speed and put on the load. There was then only a very small amount of vibration. The turbine was run in this condition for several days. It was then decided that the unit was safe and desirable to run in spare service when the other two units might be undergoing repairs.

A short time before the unit was shut down one of the engineers discovered that when the bearing oil pressure was increased above normal the vibration diminished and became nil at 30 lb. oil bearing pressure even though 15 lb. was considered the normal bearing oil pressure on the three identical units in the plant.

Even though examination showed that the bearing seemed to have sufficient lubrication at 15 lb. no good reason existed for not carrying the pressure at 30 lb.

The unit is now run in regular service alternately each month with the next best unit in the plant. Such regular service is now nearly a year old and tests with steam flow meters show it to be the most economical unit of the three identical units in the plant. Availability of the third unit for regular service enabled the station to discontinue the use of the most wasteful and undesirable unit from regular service, but the definite increase in station economy has not been ascertained.

Perry Point, Md. G. E. GEDDES.

Settings for Small Boilers

REFERRING TO the article by J. P. Greenwood in the February number of Power Plant Engineering, pages 76 to 77, the baffling arrangement as shown in his Fig. 1 could be considerably improved by installing cross-flow baffles, as with the horizontal type of baffle considerable ineffective tube surface results, as shown in Fig. 1, herewith, similar to the one baffled by Mr. Greenwood with the exception that this is a one-pass arrangement while his has two passes. With the "gap" in the tube bank illustrated in the February number, it is obvious that the gases would flow through that gap rather than where

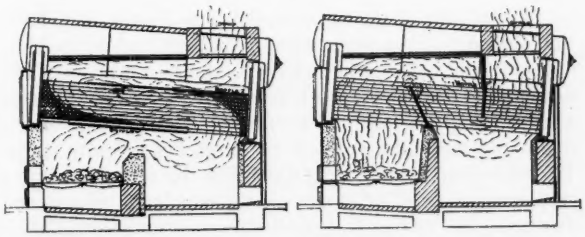


FIG. 1. HORIZONTAL BAFFLES ALLOW DEAD POCKETS
FIG. 2. CROSS BAFFLES MAKE ALL SURFACE ACTIVE

they would do more good because gases always seek the path of least resistance. With cross baffling, as in Fig. 2, the presence of that gap would make no difference and all dead air pockets would be eliminated by cross flow throughout in place of parallel flow.

Regarding the furnace walls, high grade plastic lining gives better results than fire brick. By using plastic, joints are entirely eliminated, also leakage. Plastic is anchored to the outer wall in much the same way as illustrated by Mr. Greenwood, with air cooling thrown in. In fact, a more flexible arrangement is possible with plastic.

Newark, N. J. W. F. SCHAPHORST.

Natural Gas as a Fuel

NATURAL GAS has often been called the ideal fuel and as it is now distributed over wide areas by means of pipe lines it is advisable for all power plant engineers to become more or less familiar with its properties. It is impossible to tell when one may be called upon to give an opinion regarding its value and utilization. As a rule the gas distributed comes stripped of its gasoline and usually consists of the hydrocarbon methane with some ethane, hydrogen, nitrogen, carbon dioxide and carbon monoxide, the proportions and specific constituents varying with the field from which it is drawn. One Louisiana gas runs about 95 per cent methane, Ohio gas 80 per cent methane, and a Transylvania gas 99 per cent methane. In Mexico there are wells producing practically pure carbon dioxide which is, or was, being used commercially as dry ice.

Fuel values run from about 950 to 1200 B.t.u. per cu. ft. of gas. On a straight thermal basis the gas has to sell at from 15 to 20 ct. per 1000 cu. ft. to compare with coal at from $3.50 to $4.00 per ton. It has so many advantages that the two fuels cannot be compared on a price basis alone, however, as natural gas is clean and can be delivered anywhere without dust or dirt and with very little danger. Within the capacity of the lines it can be delivered in any quantity desired and without forming deposits in the lines that require expensive cleaning.

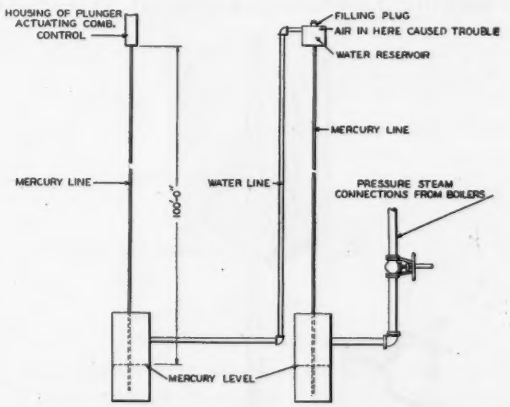
Coal handling equipment is done away with or if already installed does not have to be operated. In many cases an emergency fuel, either oil or liquefied gas will be necessary to insure continuous operation as no small size storage can be provided although it is being done on a large scale in old and formerly abandoned wells. Cost of standby service must therefore be considered.

In some cases a false furnace floor has been made by bricking over stokers so as to allow gas to be tried at very little expense and to be abandoned if it proves too expensive or gives out as it has done in some sections. Firing is simple and no steam or electric auxiliaries are needed as with coal or oil firing. Natural gas can be used alternately or at the same time in the same furnace with pulverized coal and these plants can sometimes make arrangements to buy off-peak gas very cheaply, burning coal at other times.

Springfield, O. F. PAUL.

Difficulties with High Head Mercury Columns

CONSIDERABLE DIFFICULTY in locating the source of trouble with the combustion control system recently developed in a boiler plant. The pressure balancing element consisted of two mercury columns in series as shown. It will be noticed in the piping diagram that a water leg is included between the two mercury columns. This is filled from a plug on the top of the reservoir which is supposed to be kept full to the top with water.



MERCURY AND WATER COLUMNS FOR COMBUSTION CONTROL SYSTEM

After this control had given excellent service for a long time a leak at a pipe fitting on the foot of one of the mercury columns developed. The mercury was removed and divided by weight into equal amounts for replacement after repairing the leaky fitting. It was then that the real trouble started. The most erratic performance imaginable was witnessed. The regulator was supposed to reduce the fuel-air supply to the boilers when the pressure had risen to 385 lb. pressure and

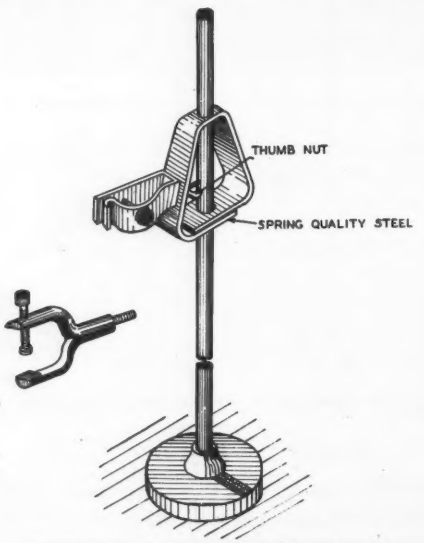
gradually increase this supply to a maximum when the pressure had dropped to 375 lb. Instead of doing this it would allow the pressure to rise to 400 lb. After adjusting so as to close off at 385 lb. the regulator would refuse to open the controls when the pressure had dropped to 350 lb. when it became necessary to do so manually. Water was added and then bled off in various amounts on the water leg. This was done to change the position of the two mercury columns but a resulting change in operation that should have followed this was not accomplished.

Finally it was decided to check up on the man who filled the water leg and reservoir. On doing this it was discovered that although at the time he filled it, it had given all indications that it was full, this was because it had been air locked. After he had replaced the plug and left it for a short time the air slug had worked its way to the top leaving considerable space for more water. The air being compressible easily explained the difficulty especially at the prevailing pressure. With such a system it is essential that the full amount of water be between the mercury columns in order to obtain proper sensitive operation. In filling, the plug should not be replaced until after forcing the mercury columns up and down a number of times to drive out any air bubbles. These will be forced to the top of the water leg. The reservoir should then be again examined and filled to the top if any drop in water level has occurred.

Milford, N. J. HARRY M. SPRING.

Work Bench or Laboratory Work Holding Stand

AS A SIMPLE and practical work bench stand that shown in the sketch will be well worth the making. It can be used for holding the numberless small articles at just the right height and angle for the work being done. For soldering it is extremely convenient. It is fitted with



CONVENIENT SMALL WORK HOLDER

different types of work holders as shown and the feature is the quick and easy adjustment for height by the simple pinching together of the spring clamping piece and sliding of it up or down.

Penacook, N. H. CHAS. H. WILLEY.

Hot Condensate to Sewer Caused Cracked Drains

AT A CERTAIN plant in Ohio the office was a separate building and had its own heating system which was low-pressure steam with gravity return. The janitor was the fireman and he seemed to have a lot of trouble with the horizontal boiler in the small basement. He ordered and used up an excessive amount of boiler compound and every Saturday afternoon had to wash out the boiler. No one in the office ever paid any attention to this because they had taken it for granted that trouble was to be expected where a boiler was concerned.

On account of the organization line-up the shop crew and the office force were entirely distinct and so the shop engineer had nothing to do with the office conditions. The new engineer, however, had charge of the drainage system and when spring arrived he found that the main storm drain did not take care of the first heavy rain storm. Investigation disclosed the fact that the terra-cotta pipe was cracked and broken into thousands of pieces and furthermore he was told that this was nothing unusual and that for years it had been necessary to replace a lot of broken drain pipe every spring.

The new engineer promptly began to investigate and traced hot water back towards the office. He then found that the janitor was using entirely too much make-up water in the boiler and what became of this was not clear for all the returns seemed to be in good condition and functioning properly. The only returns he could not check were those from the front and main part of the office and this was because there was no room between the joists and soft clay ground, in fact, there was not enough space for a cat to crawl about let alone a 165 pound man.

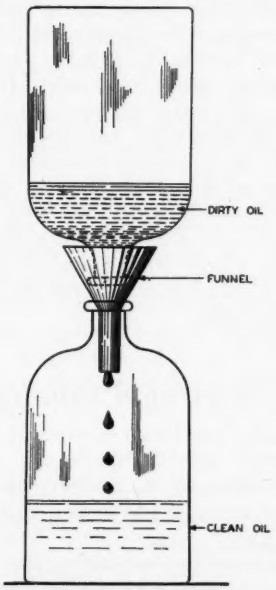
On the next Sunday, the engineer got up steam, shut the returns completely off and then tested all radiators by partly closing the inlet valve and listening to determine if steam was still rushing into them. In this way he discovered that the row of radiators in front of the office would continue to take steam in large quantities no matter whether the main return to the boiler was closed or not. As he did not wish to tear up the office floor he dug behind the shrubbery under the front windows and in half an hour discovered where all the trouble was.

The heating system, he found, had been properly designed and properly installed and must have run as intended for several years. Then evidently the return pipes from the front of the office had become filled with rust, scale and junk and whoever had attempted to clean them had found they could not get underneath the floor to do the work so they had done the easiest possible thing, which was to run a new drain line outside the front of the office to the main storm drain and to this they had connected the radiator drains. This, of course, got the radiators working promptly again and apparently everyone was satisfied, never realizing what a tremendous cost was being paid for this smart trick. Coal was wasted, boiler compound was used up by the barrel for the city water was very hard and water was wasted; the labor also for cleaning the boiler was wasted and the cost of new storm drains was added on top of all this every spring.

Moline, Ill. GEORGE P. PEARCE.

Filter Made of Two Bottles

FOR SIMPLE filtering jobs, covering a wide range of liquids, it is hard to beat the device shown in the accompanying sketch. Two bottles, a funnel and filtering material are all that is needed. Put the dirty liquid in one of the bottles. Place the filtering material (I sometimes use ordinary waste) in the funnel, and insert into the lower bottle. Then invert the bottle containing the liquid just as is done with an ordinary water bottle. It is inverted over the funnel and placed in such position that it will gradually and automatically feed while the liquid filters. It never feeds too fast.



SELF POURING FILTER

Anybody can make and operate one of these filters. An advantage of the device is that as soon as the liquid has filtered through into the lower bottle, the bottles may be reversed if desired and the liquid refiltered. The filtering medium is easily renewed. Since the bottles are made of glass the operation of the filter is always clearly visible.

Newark, N. J. W. F. SCHAPHORST.

Plant Histories Aid Future Developments

IF THE WRITING of reports is burdensome to the majority of plant engineers, how can the preparation of continuous histories of station development be made to appear worth-while? The production department of a good-sized eastern utility has answered this question to its own satisfaction by annually reporting every important feature of its station service to the president in the form of a typewritten memorandum which is bound for convenient reference. The material is assembled from a continuous record maintained by the superintendent of power from month to month, and it includes comment on all important changes in equipment, notes on major repair jobs, discussions of new developments and their outcome, and reviews of steps taken to improve economy of operation and overcome troubles which handicapped rendering the best service. This company has done a great deal of pioneering in the prime mover field within the past few years and in addition to weeding out all manner of troubles with new and untried equipment in co-operation with the manufacturers it has taken pains to put on paper a complete engineering history of these problems and the solutions attained.

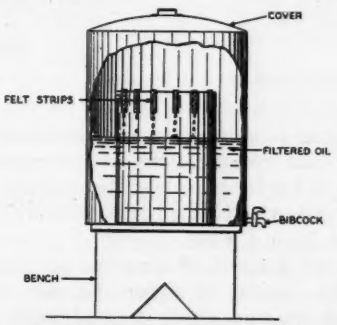
Many things of importance escape even the best memories in the operation of plants associated with significant developments in machinery, methods and interconnection; and it cannot be doubted that the practice of keeping an up-to-date history of every plant which is doing interesting work has enormous potential value in relation to future development. The monthly work can be done piecemeal without the least disadvantage and the task of annual assembly is not as formidable as it might appear when systematically handled.

Cambridge, Mass. H. S. KNOWLTON.

Capillary Attraction Employed to Filter Oil

IN THE HOPE that some reader located in a small isolated steam plant may be interested and perhaps benefited, I herewith present a description of a cheap but efficient oil filter which I made several years ago when I was engineer in a country steam plant of about 300 hp. capacity. The illustration shows the filter after completion. The sizes of the two vessels must be such that the small vessel when placed inside the larger one leaves sufficient space to allow an ample supply of filtered oil to be carried on hand.

In my case, I was fortunate enough to be able to locate about the plant two discarded galvanized iron cans, one being 22 in. in diameter and 36 in. high. For this one I had a lid made and, after cutting a hole 2 in. from the bottom, a bib cock was inserted and soldered. The other one was 12 in. in diameter and 30 in. high.



EASILY MADE OIL FILTER

This was placed centrally in the large can, the two placed upon a bench which was constructed from a pine board ¾ in. thick and 12 in. wide. Then some wool felt was secured, cut into strips a couple of inches wide. These were draped over the edge of the inner vessel with about 4 in. of their ends dropping over the top. Oil gathered from various bearings and poured into this inner vessel works its way by capilary attraction up through the strips of felt and drops into the space between the two vessels as shown. These strips of cloth filter the oil in its course from the inner to the outer reservoir. They must be removed and cleaned or replaced occasionally but this can be done without interrupting the service of the filter.

Coshocton, O. JOHN C. KAHL.

Plant Operation Problems

Action of Ammonia on Zeolite

ON PAGE 100 of the February 1933 issue, Edward P. Schinman of the Permutit Co. answered a question regarding the action of zeolite on water containing ammonia. Zeolite removes ammonia in the same way that calcium and magnesium is removed, that is by the base exchange method. In this case, determination of the time between regenerations should be made by the soap test and not by the usual method of gallons per regeneration. If this were done with appreciable quantities of ammonia the softener would actually be overrun because no account would be taken of the zeolite used by the ammonia. Further details of the control under these conditions are given by Mr. Schinman below:

"When ammonia is present in boiler feed makeup water and it is being removed by the zeolite softener, the time between regenerations of the softener should be controlled by the standard 5 drop B. & B. soap test. The reason for this is that the action of ammonia on zeolite is practically the same as hardness (calcium and magnesium) and if there is ammonia present in the water the number of gallons between regenerations of the softener is decreased in proportion to the amount of ammonia present.

"For example, assume a softener with a hardness removal capacity of 200,000 grains and that the water being softened has a hardness of 4 grains per gallon (as $CaCO_3$). The number of gallons per regeneration during normal conditions would be $200{,}000 \div 4 = 50{,}000$ gallons. If the water contains 1 gr. per gal. of ammonia (as $CaCO_3$) then the number of gallons between regenerations would be about $\frac{200{,}000}{4+1} = 40{,}000$. If the softener is allowed to run the usual number of gallons between regenerations as determined only by the amount of hardness present the softener would actually be overrun so that some hardness would slip through and tend to form a scale.

"Since the amount of ammonia in the water, and therefore, the number of gallons between regenerations of the softener, may vary, it is advisable to test the effluent of the softener at periodic intervals and to regenerate it when the softened water no longer responds to the standard 5 drop B. & B. soap test so that only zero soft water be fed to the boiler which will insure keeping it clean and free from scale."

Reversal of Generator Polarity

AN EXPERIENCE covering a case of the reversal of generator polarity may be of interest to your readers.

A small high speed alternator had a direct connected exciter of such low capacity that the brush equipment consisted of only two sets of holders and each holder contained only one carbon brush. The unit to be described was one of two that had been in operation over 5 yr. and had never given any trouble.

One day while the unit was operating alone, and the attendant had left the room the lights were noticed to flicker suddenly and then continue burning normally. An immediate examination showed nothing out of the ordinary except that the exciter voltmeter was reading reversed. There seemed no reason for this as there had been no change in operating conditions. After considerable inspection the reason turned out to be as follows:

The commutator had developed a high bar and was dirty. When the condition became severe the high bar caused the single brush to be forced into the holder and being dirty, the spring did not return the brush to the commutator immediately, the circuit was momentarily broken and the inductive discharge of the field, the exciter being shunt wound, reversed the polarity. Since this exciter could be paralleled with the other one it was necessary, at once, to correct the condition. This was done by simply lifting one of the brushes, which returned the polarity to its original condition through a reverse operation.

Brooklyn, N. Y. C. O. VON DANNENBERG.

Centrifugal Compressor

WHAT IS the maximum theoretical pressure in inches of water that will be developed by a centrifugal compressor with a 40 in. dia. impeller when running at 60 r.p.s. and handling gas with a specific gravity of 0.4 referred to air?

2. Other conditions remaining constant, does the discharge pressure vary with the gravity of the gas?

J. J. Z.

A. At impending discharge, that is at no flow, and with the discharge closed, the theoretical head developed by a centrifugal pump or compressor is expressed as $h = u^2 \div 2g$, where h is equal to the head in feet of fluid being handled, u is equal to the velocity of the impeller in feet per second and g is the gravitational constant equal to 32.2 ft. per sec. per sec. Due to internal friction, leakage and similar items, the actual head at impending delivery varies from 0.9 to 1.1 of the value as given by the theoretical formula.

In the above case the peripheral velocity is equal to 628.32 ft. per sec. This squared and divided by 64.4 gives a head equal to 6135 ft. of gas. If air is taken at 75 deg. F., 30 in. of mercury, the density is about 0.075 lb. per cu. ft. which would give a gas density of 0.03 lb. per cu. ft. A column of this gas 6135 ft. high would develop a pressure of 1.28 lb. per sq. in. which is equivalent to 35.4 in. of water. This is the maximum theoretical head the compressor would develop under the given conditions.

2. The discharge head developed in feet by a centrifugal compressor pump is theoretically independent of fluid handling as shown by the above formula but because of the difference in density the pressure developed in the casing will vary directly as the density of the fluid. For instance, if the compressor were handling water instead of gas the head of 6135 ft. would represent $6135 \div 2.31$ or 2680 lb. per sq. in. With air

of the density mentioned above the pressure developed by the blower would be 3.19 lb. per sq. in. or with the gas would be 1.28 lb. explained above. These pressures are proportional to the densities. It will thus be seen that the pressure developed in the casing varies directly with the density of fluid being handled but that the head expressed in feet of the fluid pump remains constant for the same peripheral speed. (The above calculations were made by slide rule.)

Steam Temperature

Is there a formula for determining the temperature of saturated steam at a given pressure? I know these temperatures are readily found in steam tables but I would like to know if it is possible to calculate the temperature if a person had no table.

R. E. T.

A. Such formulas can be found in steam tables and in books on thermo-dynamics but are very complex, sometimes requiring 15 or 20 terms and 3 or 4 constants which change over the pressure range. Although the only satisfactory method to determine the saturation temperature for a given pressure is by the use of steam tables, so many requests come in for a formula of this kind that we are outlining below a method of determining the formula for a limited pressure range.

In the pressure range from 70 lb. to 120 lb. ga. the temperature is given approximately by the following formula:

$T = 135\ P^{0.2}$.

Where

T = temperature of saturated steam in deg. F.

P = pressure in lb. per sq. in. ga.

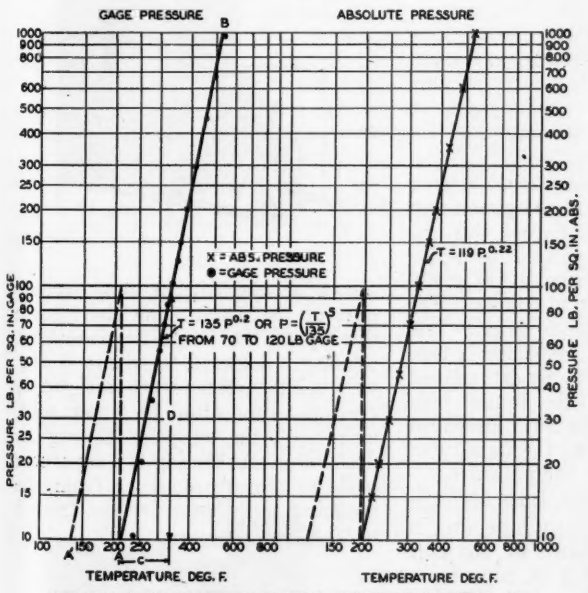


CHART FOR DETERMINING TEMPERATURE OF SATURATED STEAM AT A GIVEN PRESSURE

The method of arriving at this formula is as follows:

On logarithmic paper pressures and temperatures are plotted from the values given in the steam tables as shown by line AB. The exponent is the ratio C ÷ D as found by measuring the distance C and the distance D in any convenient units. On the original drawing, A = 1.495 and B = 7.475 in., so the exponent is $1.495 \div 7.475 = 0.2$. The constant 135 is found by finding where the line AB cuts the point where P = 1. This is done by extending the line, AB to A^1 so the constant is 135.

The points as plotted show a decided curve so that the formula, which represents a straight line, fits only a portion of the pressure range. If absolute pressures are used, the points fall much closer to a straight line and constants in the formula fit a greater pressure range.

Painting Expansion Coils

Q. Is the use of aluminum paint recommended on direct expansion coils of an ammonia system? These coils were at one time painted with red lead which in the course of time peeled off. B. A. S.

A. Painting of direct expansion coils requires the use of a material which is 100 per cent non-porous so as to prevent the infiltration of moisture in the pipe surface. Any refrigerated pipe surface which is continually frosted will not suffer from excessive corrosion nor is it difficult to keep paints on such a surface. Surfaces which are alternately frosted and defrosted are extremely difficult to keep covered with any coating and the surface is subject to extreme corrosion.

Red lead and pure linseed oil are one of the best initial coats for refrigerated pipe surfaces although in itself it is not suitable for protection from the outside washing action which occurs when defrosting. It is always best to apply a finishing surface of a hard wearing quality over the top of the red lead and linseed oil.

Aluminum paint has been successfully used over the top of the red lead and linseed oil priming coat, although aluminum paint is not recommended for evaporator surfaces because it does somewhat reduce the heat transfer. Some of the varnish-like opaque rust preventatives such as are used for coating machinery parts have been successfully applied to refrigerated pipe surfaces and have stood up as long as two seasons on pipe lines which were continually frosting and defrosting.

Answered by M. W. Garland, Superintendent Field Erection Division of the Ice and Refrigerating Machinery Department of the Frick Co., Waynesboro, Pa.

Refrigeration Cooling Systems

Q. We have a ¾ t. ice machine which requires from 2 to 5 gal. of cooling water per minute. This water is taken from the lake and varies in temperature from 32 to 85 deg. F. At the present time this water is wasted to the sewer. We would like to know if it would be economical to use a closed cooling water tank on the same principle as the hot water system. B. A. S.

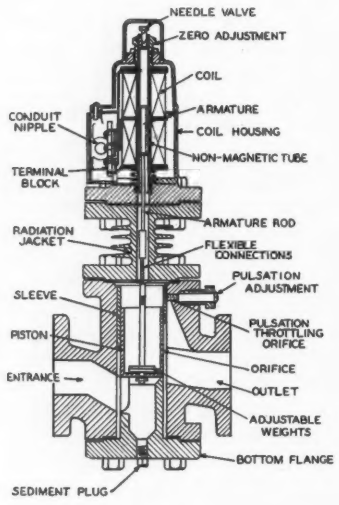
A. The ice machine is in reality a heat pump and the heat taken from the refrigerated space or from the ice and water being frozen must be carried away by some media. This is usually done by means of the cooling water. If the water is used over and over again in a closed system some sort of spray pond or cooling tower must be included to transfer the heat from the water to the atmosphere.

With the small amount of water used in your case it is questionable if a system of this kind would be economical unless your pumping costs are very high or water is scarce. If the water supply is limited the cooling water might well be run back to the lake and not to the sewer.

New Equipment

Area Flow Meter

FOR MEASURING the flow of certain fluids such as heavy oils, chemicals and food stuffs, the Brown Area-Type flow meter has been developed by The Brown Instrument Co., Philadelphia, Pa. This instrument is installed in the main pipe line so that no seals against contact of the fluid measured with registering mechanism or auxiliary piping to transmit pressures are required. Fluid passes direct through the meter body and orifice, while indications of flow are transmitted electrically to indicating or recording mechanisms or both, located at any desired point at a distance from the meter body.



As the fluid enters the meter body it strikes the bottom of the piston, which as it is free to slide vertically upward, will be lifted, exposing a section of the rectangular orifice in the sleeve. As the fluid escapes through this orifice, it rises through the pulsation throttling orifice in the vacant section above the piston. This will exert a vertical downward force on the piston, equal to the area of the piston times the pressure of the fluid on the outlet side of the orifice.

The piston will come to rest when the force exerted upward on the piston is exactly equal to the opposing force, which is made up of the outlet pressure and the weight of the piston and armature.

It works out that the difference between entrance and outlet pressures is a constant quantity, depending upon the weight of the plunger divided by the area of the piston, so that the meter will operate to maintain a fixed pressure drop across a variable orifice.

Position of the piston is definitely measured by the inductance bridge system, as used in the Brown Electric Flow Meter. As the armature travels vertically in the non-magnetic tube, surrounded by a divided inductance coil, another armature in the indicating mechanism will assume corresponding positions, which will be a measure of the area of orifice opening in the meter body, hence of the rate of flow. Calibration is to give equal increments in deflection for equal increments in flow, hence scales and charts are evenly graduated. The forces which shift the piston position are actually as great at small flows as at large flows, giving accuracy at all readings.

Piston area of 5 sq. in. enables the meter to operate with a low total pressure drop in the line, yet respond to any changes in the flow conditions. Depending upon the application, the meter-body is furnished with either a steam jacket or a radiation jacket mounted just below the inductance coil.

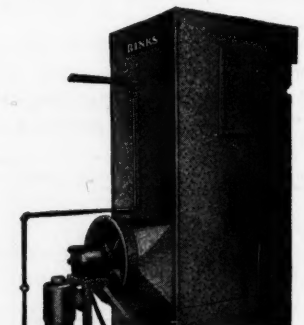
Range of the meter is adjustable by adding weights to the piston cup and by installing different size orifice sleeves. For measuring water the ranges vary from 0-150 g.p.h. minimum to 0-2000, maximum. For fluids having a specific gravity less than that of water, capacity is less, the actual capacity being determined from the ratio of the square root of the density of the fluid measured to the square root of the density of water at the same temperature.

The meter is furnished only in 2 in. size. Where the pipe line is smaller or larger than 2 in., the user inserts a section of 2 in. pipe for a distance of 15 pipe diameters on each side of the point in the line where the meter body is to be installed.

Three types of register are available: Chart recorder; chart recorder with indicating scale; dial indicator. The inductance-bridge principle makes it possible to operate two receiving instruments off one meter-body—as a circular chart recorder and a circular dial indicator—which permits installing the indicator near the operator's post and the recorder in the engineer's office.

Indoor Cooling Tower

THESE TOWERS, made by Binks Manufacturing Co., Chicago, Ill., are a self-contained unit, with or without water circulating pump. Fan in the base forces air through deflectors to give uniform distribution, while water is sprayed downward from the top of the tower and falls into a pan at the bottom, whence cooled water is drawn for circulation. Spray nozzles are Roto-jet whirl-chamber type. The pump,

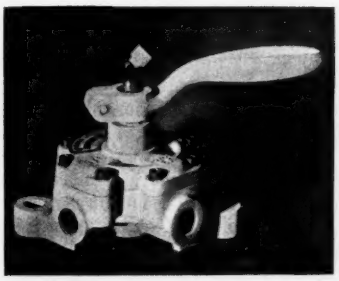


shown at the bottom, may bypass part of the water from the pan to the top of the tower for recooling. Cooling is claimed to within 6 deg. of wet bulb temperature and yearly average evaporation of 2 per cent, make-up being supplied through a float valve. At the top is a separator baffle to remove moisture from the outgoing air. Capacities are from 5 to 50 g.p.m.

HAYDEN-DAVIS ENGINE CO., Waukesha, Wis., is marketing a 4-cylinder, high-speed, single-acting steam engine for isolated power plants and marine use, in size of 100 rated horsepower, weighing 24 lb. per hp. and occupying 15 sq. ft. of floor space.

Disc Valve

IN THE Unitite valve made by Hanna Engineering Works, Chicago, Ill., the valve disc seats on the bonnet, rotating between reversals on two eccentric points while in contact with the seat to prevent circular lines of contact or scoring. Disc and stem are lubricated from an oil well in the stem, the two-piece disc and stem rotating as a single unit but with the disc free to find its seat, regardless of lateral force on the



stem. Piping is to ports in the valve body, two inlet ports being provided for convenience in piping and so that the valve may be used as straightway, 3-way or 4-way. Operating handle may be adjusted to the most convenient position, a 40-deg. movement giving full port opening and an 80-deg. movement reversal of flow. Seating the disc on the bonnet and securing bonnet to body with socket-head cap screws permits removal of the bonnet and regrinding of disc and valve seat with no disturbance of pipe connections. Sizes are 3/8 to 1¼ in. for pressures of air, oil or water up to 250 lb.

Thrustor-Operated Control Valve

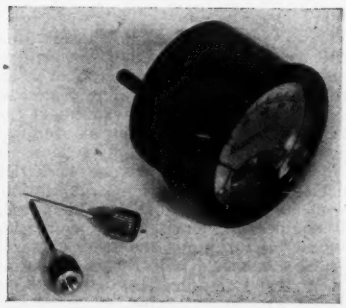
IN THIS NEW valve of the Northern Equipment Co., Erie, Pa., for centralized remote control of flow of gases or liquids under pressure, a

General Electric Co. Thrustor is mounted at the side on a bracket bolted to the valve bonnet. Action is by a straight line, constant-pressure, hydraulic cylinder thrust in one direction, the weight returning the valve to the original position when the electrical circuit is broken.

Control is by push button or time switch, with external adjustment to regulate speed of valve movement. Speed of operation can be up to 40 times a min. and power is sufficient for heavy, viscous liquids.

The Electrynx

AN EXTREMELY SIMPLE instrument suitable for measuring the acid content of solutions and mixtures used in food, beverage, pharmaceutical, fermentation, and similar processes has just been announced by the Westinghouse Electric and Manufacturing Company. The complete outfit, known as the "Electrynx" kit, consists of an indicating instrument with mounting clamp, a set of six pointed electrodes, two



knurled chucks for attaching the electrodes to the instrument or to other terminals, two machine screws and nuts for mounting the electrodes in any testing fixture.

It can be used to measure the relative electrolytic effect of any liquid or solid in which the electrodes can be placed. Among other things its uses include testing hardness or salinity of water, testing uniformity of greases, control of acidity of petroleum products, control of food products, dyes and pigment, electroplating, soil testing, fermentation processes, milk and milk products, and paper manufacture.

This device known as the "Electrynx" is a sensitive microammeter which measures the electromotive force across two dissimilar metals when these metals are inserted in materials having acid or alkaline reaction or a trace of salt. The instrument measures the relative acid, alkaline, or salt content. The terminals of dissimilar metals are screwed into the terminals on the instrument and inserted into the substance to be tested.

Breakers to Replace Fuses

ANNOUNCEMENT has just been made by the General Electric Co. that a complete line of small circuit breakers, rated up to 600 volts and 600 amperes, and designed for the control and protection of industrial circuits, house service entrance, branch circuits, refrigerators, ranges, etc., has been placed on the market. In addition to offering such inherent advantages as speedy restoration of service and temperproof protection, these new breakers, designated as AF-1, employing a unique principle of arc interruption, operate quietly and permit no external arc. The interruption takes place within a closed metal chamber. When an over-current trips the breaker, the contacts are disengaged within the metal chamber. The arc, which is drawn between the contacts, generates a pressure which increases the resistance of the arc path so rapidly that the circuit is interrupted in 0,008 of a second.

These new breakers are trip-free from the operating handle and cannot be held in the closed position when an overload exists on the circuit. The "on" and "off" positions are clearly marked on the front cover and a yellow target appears in view when a breaker opens on an overload. No external arc is visible and only the click of the trip mechanism and the appearance of the target indicate that the breaker has tripped.

Overload tripping of the breakers is initiated through a bi-metallic thermal strip which, when heated by over-current, deflects and actuates the trip mechanism. This device has an inherent time lag inversely proportional to the magnitude of the overload. A short circuit will cause almost instanteous tripping. The large breakers have both thermal time delay and instantaneous tripping, a spring toggle providing sure and speedy operation. All poles of multiple breakers operate simultaneously.

The breaker parts are enclosed in a housing of textolite and provision is made for convenient mounting of the breaker in panelboards, deadfront distribution boards, or individual metal enclosures. All sizes of the AF-1 breaker are designed to fit the ordinary service entrance box.

Self-Priming for Centrifugal Pumps

In the system of the Pennsylvania Pump & Compressor Co., a small motor-driven rotary vacuum pump unit is mounted on the main pump to draw air from that pump and its suction line. Starting of the vacuum pump is by push button, remote control or change in the water level or head. When the main pump is fully primed, its motor is started. With establishment of normal pressure in the discharge line, the vacuum pump unit stops, but should the main pump lose its prime, it will stop and the priming unit will start up to repeat the cycle. The main pump cannot start nor remain in operation unless it is fully primed.

Abram E. Fitkin

Since 1900 Mr. Fitkin has been among the financial leaders in the public utility field. He began with railroad securities in Boston and rose steadily until he was manager of Pelser, Welker & Co. Among the properties which he helped to promote were National Public Service Corp., Western United Corp., Inland Power and Light Corp. and Pacific Public Service Co. His activity was largely in promotion and combination, then selling to an investment house or a holding company. His philanthropies were widespread, often in the fields of medical service and research, including a memorial hospital in South Africa and a memorial pavilion with endowment for research on children's diseases at Yale University. He was 54 yr. of age at the time of his death on March 18.

J. Wm. Link

J. Wm. Link, for many years Chief Hydraulic Engineer of Byllesby Engineering and Management Corporation, died on April 14 after a long illness. His funeral was held from his residence at 2425 Hartzell Street, Evanston, at 3 P. M. Monday, April 17. Interment was at Memorial Park Cemetery, Evanston. Mr. Link had been a member of the Byllesby organization for 23 years. He was a member of the American Society of Civil Engineers, the Boston Society of Civil Engineers and Western Society of Engineers.

Corrosion Resistant Steel Boiler Tubes

Timken Steel and Tube Co., Canton, Ohio, is offering seamless steel tubes for boilers and superheaters in three new compositions. The MM-9 steel is an alloy with high strength at elevated temperatures, suitable for high-temperature, high-pressure installations where only small "creep" changes are allowable.

DM steel has even higher creep strength, for requirements that are difficult to meet, with a high limiting unit stress at a given temperature before definite rate of flow or creep is produced. Both the above are free from temper embrittlement. Nickel-molybdenum steel has high resistance to general corrosion with no sacrifice of mechanical properties or ease of manipulation.

New indirect heating surface to be known as the K-Fin Bentube Heater is announced by The Griscom-Russell Co., for use in heating, ventilating, air conditioning and cooling systems. K-Fin extended surface is attached to the tubes by a process that gives continuous metallic contact, so permanent as to be suitable for high temperatures. Initially bowed tubes are used, each free to expand independently and increase its curvature on increase of temperature. Units are being distributed through Hitchen Engineering Co., Inc., 155 E. 44th St., New York City.

Speed reducer and motor combined as a single unit is announced by D. O. James Manufacturing Co., Chicago, available from ½ to 20 hp. with a wide range of ratios and speeds. Gears are of the continuous-tooth, herringbone construction mounted on anti-friction bearings, running in a bath of oil, making a compact, space saving drive.

News From the Field

"Engineering Week" in Chicago, June 25 to 30, will bring together the greatest number of engineering societies ever assembled in this country. The American Association for the Advancement of Science which includes many coöperating organizations will hold all its sessions on Basic Science during the same week that nineteen other engineering organizations are meeting in Chicago. More than 100,000 engineers comprise the membership of these organizations and special awards by many societies will be made during this time. "Engineers' Day" at A Century of Progress promises to be of particular interest because of the spectacular events planned for the morning assembly. It has just recently been announced that Juan de LaCierva, inventor of the autogiro, is to pilot his plane to Chicago and land in Soldiers Field in the midst of the assembled engineers. After landing, Mr. de LaCierva will become the recipient of the Guggenheim Award for outsanding aviation achievements for the year 1932.

Northern Equipment Co., Erie, Pa., announces the appointment of George W. Neale as district representative for the State of Florida, with the exception of Jefferson County and the counties west thereof. His office is located at 504 East Lafayette St., Tampa, Florida.

Babcock & Wilcox Co. announces the addition of Mark R. Woodward to its cement equipment division. For the last 15 yr. Mr. Woodward has been assistant chief engineer of the Lehigh Portland Cement Co., with headquarters in Allentown, Pennsylvania, and an active member of the A.I.E.E. Mr. Woodward will be located in the Chicago Office of the Babcock & Wilcox Co., at 20 North Wacker Drive.

Daniel W. Mead and Charles V. Seastone announce that their engineering business will hereafter be conducted by their successors, Harold W. Mead, Clayton N. Ward and Henry J. Hunt, former associates who will continue the business at the State Journal Building, Madison, Wisconsin, under the name of Mead, Ward and Hunt, with Clayton N. Ward as chief engineer. Daniel W. Mead and Charles V. Seastone will continue their association with the new firm in advisory capacities.

Announcement has just been made by the American Oil Burner Association that the 10th National Oil Burner Show and Convention to be held at Hotel Stevens in Chicago, June 12-16, will have a program this year calling for two sessions, one on the morning of the 14th and one on the morning of the 16th. The dealer-day program is arranged for June 14 and an engineering session, for the benefit of the entire industry, will be held on June 16.

Announcement is made by M. H. Detrick Co., Chicago, Ill., of the appointment of the Insulation and Refractories Co. as agents in the Buffalo territory with offices at 841 Elmwood Ave., Buffalo, N. Y.

The Superheater Co. on May 1 moved its Pittsburgh, (Pa.) office to American Bank Building, 600 Grant Street, from Union Trust Building. The office remains in charge of R. L. Ehmann, representing the Industrial Department.

A new publication describing a new photo electric lighting control unit has recently been announced by Westinghouse Electric and Manufacturing Company. This new apparatus, known as the Photolux is a reliable and accurate device that operates to turn electric lights on or off when daylight decreases or increases in intensity to a predetermined value.

THE DUNBAR ENGINEERING Co. announces the appointment of the Washington Engineering Co., 601 13th St., N. W., Washington, D. C., under the management of P. N. Israel, as its representative for Edward valves in the District of Columbia.

THE AIR CONDITIONING department of the General Electric Co. announces the appointment of the Air Conditioning Corporation as the G-E air conditioning dealer in Chicago. This company, of which C. J. Bassler is president, has showrooms in 221 North LaSalle Street, Chicago, and will sell the complete line of G-E air conditioning equipment, including the oil furnace.

AT THE ANNUAL meeting of the stockholders, in Chicago, Evans Woollen, president of the Fletcher Trust Co. of Indianapolis, was elected a director of Link-Belt Co. for a term of 3 yr. The following directors were re-elected for the 3 yr. term: George P. Torrence, president, Link-Belt Co., Alfred Kauffmann, vice president; and Henry F. Pope, president, National Malleable & Steel Castings Co., Cleveland.

CHARLES EDWARD EVELETH, 57, vice-president of the General Electric Co., died at Schenectady, March 25, following an illness of several months. He had been with the company since his graduation from Worcester Polytechnic Institute in 1899, and had been a vice-president since April, 1927. As vice-president, he was at first associated with C. C. Chesney and W. R. Burrows in the management of the manufacturing department of the General Electric Company. In 1929 he was transferred by President Gerard Swope to the engineering department in association with Vice-president E. W. Allen. There he had charge of the designing engineering departments and of the works laboratories attached to each major manufacturing plant.

PACIFIC COAST tube cleaner business of both The Lagonda Manufacturing Co. and Liberty Manufacturing Co., Elliott Co. organizations, in the past handled through a sales agency, is now carried on direct with the customer. F. A. Calmus is the Pacific Coast manager for Elliott Co. and associates. He and his staff, located at 813 Rialto Building, San Francisco, California, carry a small stock of tube cleaners and parts. A warehouse has been opened in Los Angeles at 1732 East Seventh Street with C. W. Cooper, sales engineer, in charge. S. C. Miller, sales engineer in charge at Seattle, Washington, is located at 414 Vance Building.

REFRACTORY & ENGINEERING CORP., of 381 Fourth Avenue, New York, has purchased the former plant and equipment of the Merion Magnesia Corporation at Valley Forge, Pa. The new plant, as well as the present plants at Bayway and Netcong, N. J., will be used for the manufacture of the new insulations developed by the refractory company.

THE NATIONAL ALUMINATE CORP., Chicago, has awarded a contract for an addition to its factory in Clearing, Illinois. This addition will increase the floor space by 40 per cent. Construction will begin immediately and is to be finished June 1.

JOHN H. SMITH, formerly of the Westinghouse Elec. and Mfg. Co. and connected with condenser service since 1910, has been appointed vice-president of the Condenser Service and Engineering Co., Inc., with headquarters at 61 Broadway, New York City. In addition to many patents on condensers and auxiliary equipment, he has devised the Balanced Natural Flow Condenser.

JOHN S. HAYES has been appointed by Plibrico Jointless Firebrick Co. as its distributor in Toledo, Ohio, with headquarters and warehouse at Baier Transfer and Storage Co., 347 So. Erie St.

DIRECTORS OF THE Square D Co. have elected the following officers: F. W. Magin, president; T. J. Kauffman, chairman of the board; H. S. Morgan, secretary-treasurer; J. H. Pengilly, L. W. Mercer, Vernon Brown and Carlton M. Higbie, vice-presidents.

A. W. FRANCE, president of the France Packing Co., died at his home on March 8th, at the age of 65 yr. after 2 yr. of ill health. He founded the company 37 yr. ago and has retained continuously for the last 15 yr. the same personnel and organization which, in accordance with his instructions will carry on the business. J. A. MacPeak, former treasurer has been elected president.

W. P. THOMAS has been elected president of the Diamond Power Speciality Corp., Detroit, Mich., and of the Diamond Specialty, Ltd., Windsor, Ontario, Canada, to succeed Norman L. Snow, who died January 27th.

SUBCOMMITTEE No. 2 of the Sectional Committee on Standardization of Pressure and Vacuum Gages of the American Society of Mechanical Engineers, 29 West 39th St., New York, has just prepared a proposed list of definitions for the parts of pressure and vacuum gages of the dial type.

H. C. BARNHURST, Middle-West representative of the Cement Sales Department of The Babcock & Wilcox Co., died of heart failure, March 18. Mr. Barnhurst at the time of his death was 60 yr. old and had been in the employ of the Fuller Engineering Co., Fuller Lehigh Co. and The Babcock & Wilcox Co. for a combined period of 29 yr. He was well known for his activities in the early development of pulverized fuel. Previous to his becoming chief engineer of the Fuller Engineering Co. and advisory engineer of the Fuller Lehigh Co., he was engineer for the Lehigh Portland Cement Co., associated with Professor R. C. Carpenter of Cornell University and superintendent of the Diamond Portland Cement Co.

THE SWARTWOUT Co., Cleveland, Ohio, has appointed George H. Thomson, who has been associated with the company for 10 yr., as New England representative, with headquarters at 58 Brookline St., Cambridge, Mass.

PRELIMINARY NEGOTIATIONS are completed for a meeting in the Engineering Societies' Building in New York next September 11 to 16 of an international committee on the testing of all types of internal-combustion engines. This committee is known officially as Advisory Committee No. 19 of the International Electrotechnical Commission.

The first meeting of this international committee was held in Stockholm in July, 1930. The committee devoted part of its efforts to the preparation of a standard specification and information form which, when completed, will be available for use when international tenders or estimates are desired. Good progress has been made toward the completion of this document, Part I of the I.E.C. Publication on Internal-Combustion Engines, by correspondence since that meeting and it is hoped that definite agreements may be reached concerning it at this year's meeting. Part II, Rules for Acceptance Tests, will also be considered by the committee at its next meeting.

For the Engineer's Library

HIGH SPEED DIESEL ENGINES. By Arthur W. Judge. Published by D. Van Nostrand Co., 250 Fourth Ave., New York, N. Y. 5½ by 8½ in. 239 pa.. Paper bound. Price, $3.25.

A very interesting volume dealing with Diesel engine development from the English standpoint. The illustrations, with the exception of one or two pages, are all of English engines and should be of unusual interest to American readers familiar only with American design. This is an elementary textbook on theoretical and practical aspects of high speed engines with special reference to air craft and automobile service. British motor vehicle manufacturers have not been long in appreciating the advantages of high speed Diesel engines for there are now about 16 different makes on the road. One of the interesting chapters in the book is the experience of the London General Omnibus Co. with four types of engines in omnibus service.

RULES FOR THE CONSTRUCTION OF UNFIRED PRESSURE VESSELS, which includes rules for fusion process in welding, has been published by the American Society of Mechanical Engineers, 29 W. 39th St., New York City. This 96 page booklet, which is Section 8 of the A.S.M.E. Boiler Construction Code, is paper bound and sells for $0.65 (A.S.M.E. members, $0.55.)

CLINKER FORMATION AS RELATED TO THE FUSIBILITY OF COAL ASH is the title of Bulletin 364 published by the Bureau of Mines and is available from the Government Printing Office, Washington, D. C., for 10 cents. This is a 71 page paper bound volume prepared by P. Nicholls and W. A. Selvig, with an appendix by E. B. Ricketts.

AIR CONDITIONING FOR COMFORT. By Samuel R. Lewis. Published by Engineering Publications, Inc., 1900 Prairie Ave., Chicago, Ill. 5½ by 8½ in., 236 pa. Cloth bound. Price, $2.

A simple and logically arranged text on air conditioning and air conditioning equipment beginning with an explanation of the terminology and a description of the instruments or tools by which air conditioning is accomplished; the needs of the human body; the influence of the type of heating system on the design; calculations for air conditioning requirements; design of distribution systems; computations for an actual design. In the back is a large sized chart to facilitate calculations.

VIBRATION PREVENTION IN ENGINEERING. By Arthur L. Kimball. Published by John Wiley & Sons, Inc., New York. Size 6 by 9 in., 140 pages, cloth. Price, $2.50.

This book presents in concise form a resume of the various aspects of vibration prevention encountered by the author in the research laboratories of the General Electric Co. It is intended to serve as a reference work for practicing engineers and as a textbook for students. The development, although of necessity mathematical, is direct and logical with long analytical developments not essential to understanding the basic logic involved, omitted.

PROCEEDINGS, 1932. Published by the American Society for Testing Materials, 1315 Spruce St., Philadelphia, Pa. Size 6 by 9 inches, paper. Part I 1071 pages, Part II 824 pages. Price each part, $5.50 paper; $6.00 cloth; $7.00 half leather.

Part I contains the annual reports of the Society Committees, technical papers and standards. Papers appended to the committee reports include a summary of present-day knowledge of corrosion-fatigue of metals and on the significance and limitations of fatigue test results, a correlation of tension, creep and fatigue tests of 0.17 per cent carbon steel at elevated temperatures and a cooperative study of Charpy notched-bar impact properties, magnetic properties and structural stability of the 18 per cent chromium, 8 per cent nickel, stainless steels under different conditions of treatment. In addition to data on other non-ferrous metals and non-metals in the cement, fuel and oil fields, there are included 85 tentative standards.

Part II includes technical papers and discussions presented at the annual meetings. These papers cover the entire ferrous and non-ferrous metal range and non-metallic properties including textiles, asbestos, rayon, Portland cement and testing machines.

A.S.T.M. Tentative Standards, 1932. Published by the American Society for Testing Materials, 1315 Spruce St., Philadelphia, Pa. Size 6 by 9 in.; 1236 pages; cloth $8.00, paper $7.00.

This volume includes all of the 226 tentative specifications, test methods, definition of terms and recommended practice effective as of October 31, 1932. Of this number 47 are accepted for publication the first time. This volume is issued annually by the Society and includes all of the tentative standards in effect at the time of publication. The term tentative is applied to a proposed standard which is given approval by the committee in charge and which is published for one or more years to elicit comment and criticism before it is formally adopted and issued as a standard, although in the trial stage these tentative standards are in wide use through their careful promulgation. In addition to tentative standards the book proposed additions to standards already published to elicit criticism before final action is taken.

STRENGTH AND STABILITY OF CONCRETE MASONRY is the title of Bulletin No. 251 published by the Engineering Experiment Station, University of Illinois, Urbana, Ill. These tests of strength and stability of concrete masonry walls were made to establish the relations between the physical properties of walls and those of the building units and mortar used. The reports of the test cover 36 pages. The booklet sells for $0.20.

HEAT TRANSMISSION. By William H. McAdams. Published by McGraw-Hill Book Co., Inc., New York, N. Y. Cloth bound, 6 by 9 in., 371 pages. Price $5.00.

It is seldom that a field as broad and important as heat transmission acknowledges a single authority, yet Professor McAdams has played this important role for many years and, in spite of intense research and investigations in all parts of the country, he remains the acknowledged authority. It is fortunate, therefore, that the first comprehensive modern text on this subject sponsored by the Committee on Heat Transmission of the National Research Council should come from his pen.

Heat transfer plays an important part in practically every industry. Investigations and literature have been extremely profuse but difficult to correlate and reduce to a common basis. Professor McAdams has done this and presented the results as formulas and graphs carefully constructed to give due weight to all the data available yet make the results available for design purposes.

As a comprehensive text covering all phases of heat transmission for students and practicing engineers, the text is brief but extensive references remedy this. This brevity may handicap the casual reader interested in a specific problem, a point anticipated by the author in the preface as he says, "it is the purpose of this book to present fundamentals rather than to deal with the details of individual problems and special cases."

All types of heat transfer involving radiation, conduction and convection are covered with chapters on dimensional analyses and flow of fluids. An appendix contains tables and charts of thermal conductivity, specific heats, heats of vaporization, viscosities and tables of miscellaneous data useful in solution of problems.

STANDARD HANDBOOK FOR ELECTRICAL ENGINEERS, Sixth Edition. Prepared by a staff of specialists, with Frank F. Fowle as Editor-in-Chief. Cloth, 4½ by 7 in., 2816 pages, illustrated. Published by McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York, N. Y. Price $7.00.

One feels at a loss in attempting to review a book of this type and magnitude. The range of its subject matter is so great and the amount of mental effort it represents so vast that it is difficult to overcome one's sense of amazement at seeing it between the covers of a single book. It is an excellent piece of work, and offhand at least we would judge it to be more complete than any similar volume available. It should be of value to anybody connected with the technical side of the electrical field, as well as to those in allied fields.

Fundamentally, this sixth edition is a revision of the fifth edition, but because of additions and new sections is about 30 per cent larger. In terms of subject matter it is said to be more than three-fourths a new book. Every section was thoroughly revised and brought up-to date and many parts were rewritten. In plan it follows previous editions. The sectional or unit system of arrangement adopted in the first edition has been retained and the same editorial policies which governed the preparation of the fourth and fifth editions have been followed in the present.

Some subjects previously covered in other sections have been given complete sections. Section 19, for instance is new and covers the numerous applications of electric heating, melting, welding. Section 27 also is new and covers the subjects of electron tubes and electric wave filters. Section 24 in the preceding edition comprised the standards of the A. I. E. E. as revised to the year 1922 but the later revisions became so comprehensive that it is now out of the question to reproduce them in a handbook. The general subject of codes and standards is treated in a new article in Section 28 and the latest A. I. E. E. standards are listed there by title.

The binding is excellent as is also the typography and the paper. It has a comprehensive index and each section has its separate bibliography.

THE A. S. H. V. E. GUIDE, 1933, Eleventh annual edition, 6x9 in. Cloth, illustrated, 608 pages of text, 180 pages of catalog and 64 pages of membership roll. Published by the American Society of Heating and Ventilating Engineers, 51 Madison Avenue, New York, N. Y. Price $5.00.

This edition of the standard reference volume on heating, ventilating and air conditioning appears in an entirely new "dress" and the contents have been extensively enlarged. Eleven new chapters are to be found. Chapter 3, dealing with transmission losses presents an entirely new set-up of tables with coefficients of transmission based upon the latest investigations of the A. S. H. V. E. research laboratory in Pittsburgh and recent data obtained at the Experimental Engineering Laboratories of the University of Minnesota. Chapter 14 gives additional information of heating boilers.

The American Society of Heating and Ventilating Engineers new Ventilating Standards, adopted in 1932, are included in The Guide with other important data in Chapter 22, relating to Ventilating and Air Conditioning for Comfort and Health. Much of the information came from coöperative studies at the School of Public Health, Harvard University. Considerable information heretofore unpublished will be found in Chapters 24 and 25 and the data on Air Duct Design (Chapter 33) has been amplified and made more useful by the introduction of more complete examples, showing the methods of determining accurate duct sizes. The section describing Test Instruments and Methods (Chapter 39) is new material. Chapter 36 is devoted to Natural Ventilation and presents new data. Among the chapters, which have had extensive revision are Chapter 4, Infiltration Heat Losses; Chapter 6, Radiators and Gravity Convectors; Chapters 9 and 10 dealing with Steam Heating Systems; Chapters 16, 17 and 18 dealing with Fuels and Combustion; Chapter 38, Fans and Motive Power; and Chapter 43 on Smoke and Dust Abatement.

WATER PURIFICATION CONTROL. By Edward F. Hopkins. Published by Williams & Wilkins, Baltimore, Md. Cloth, 5 by 8 in., 124 pages. Price, $1.75.

Perhaps no utility has as widespread and important influence on the general public as that of the public water system. No matter how well designed a water treatment plant may be, its product is dependent to a great degree on the knowledge and ability of the man operating it. This book written in simple language and with a logical arrangement is intended as a manual for the operator. Coagulation, sedimentation, filtration, disinfection, tastes and odors are discussed in separate chapters while at the end of each chapter numerous references are given for those interested in going further into the technical details. The book is well illustrated with practical and usable supporting data.

RESERVES, a 68-p. paper-bound book, price, $1, is issued by National Industrial Conference Board, Inc., 247 Park Ave., New York City, dealing with The Situation Confronting Industry, The Legislative Outlook, Essentials of an Unemployment Reserve Program. Developments covered include recent activities in Wisconsin, New York, Ohio, Massachusetts and Connecticut, also of the Six-State Committee and the American Federation of Labor. Responsibility is placed on the employer for provision for regular workers during usual fluctuations but not for depressional unemployment; on employes for providing from their own incomes against contingencies; on society for relief not covered by the obligations of employers and employes. Fundamental policies are outlined, including amount and duration of benefits, creation and administration of reserve funds and a discussion of compulsory legislation and voluntary private plans.

MECHANICAL POWER TRANSMISSION From Motor Drive to Industry is the title of a series of 50 weekly reports by Robert W. Drake covering transmission by belting and other means, and discussing design, maintenance, production and costs. The work is being sponsored by the American Leather Belting Assn. and the Mechanical Power Engineering Associates to meet the needs of millwrights, maintenance men and plant executives. The series will be sold by subscription by American Leather Belting Assn., 41 Park Row, New York City. Also monthly instruction and discussion meetings are being held with Mr. Drake in New York, Boston, Philadelphia and Chicago and groups are in process of organization in Buffalo, Atlanta, Houston, Memphis, Toronto and other cities. The effort is to place the purchase and use of mechanical power drives on an engineering basis so that the best form of drive will be used in each instance for the service required.

RESULTS OF MUNICIPAL Lighting Plants is the title of an 88 page booklet written by C. F. Lambert, published by the Burns & McDonald Engineering Co., Interstate Bldg., Kansas City, Mo. The second edition of this book has been enlarged to cover over 200 cities and the 1932 rate schedules have been added. The price of the book is $1.00.

MECHANICAL WORLD, ELECTRICAL POCKET BOOK, 1933. Cloth, 337 pages, 4x6 in., illustrated. Emmott and Co., Ltd., Manchester, England. Price 1s, 6d.

This little book, which is always useful makes its appearance this year in its 26th edition. It contains much practical data and information useful to engineers and users of electrical equipment. Its contents cover, electrical units, D.C. and A.C. Generators and Motors, Turbo-alternators, Rotary Converters, Motor Converters, Rectifier, Transformers, Motor Starters and Controllers, Electrical Calculations, Accumulators, Cells, Transmission Cables, Wiring, Lighting, Estimating, Switchgear, Fuses, Measurements and Testing, Meters, Welding and Cutting, Power Plant Operation, Electric Traction, Mathematical and Data Tables.

McLEOD & HENRY CO., Troy, N. Y., has just issued a folder on Steel Mixture firebrick, high temperature fire cement and plastic refractories which deals with the uses and characteristics of these refractory products.

DIESEL ENGINE GOVERNORS, their operation and results are discussed in a bulletin just published by the Woodward Governor Co., Rockford, Ill.

TWO BULLETINS have recently been published by the Engineering Experiment Station, Ohio State University, Columbus, Ohio, which are of interest to power plant operators. The first circular, No. 29, gives the details of a method for determining values of different fuels for power plant use. It was prepared by H. M. Faust and is available for free distribution. The second bulletin, No. 75, is an economic study of the use of Cambridge coal with underfeed stoker equipment. It was also prepared by H. M. Faust. This bulletin sells for 25 cents, but a limited number are available for free distribution.

USE OF STEAM JET EJECTORS with flash evaporation refrigeration equipment is discussed in a booklet just published by the Elliott Co., Jeannette, Pa. Vacuum refrigeration is at present receiving wide spread attention for use in connection with air conditioning and process cooling and the bulletin describes typical applications, the apparatus and its control, first cost and operating economy as well as specific process applications.

MECHANICAL DRIVE TURBINES with built-in reduction gearing are described in Bulletin H-8 published by the Elliott Co., Jeannette, Pa. These units provide a compact arrangement for use with mechanical drive turbines up to 100-hp.

GRAIN SIZE CHART for the classifications of steels has just been published by the American Society for Testing Materials, 1515 Spruce St., Philadelphia, Pa. This chart, 9 in. high and 32 in. long, contains 16 microphotographs of grain sizes from 1½ to 96 grains per square inch. This new tentative standard is the result of laboratory experiments extending over a period of 10 yr. The A. S. T. M. designation of the chart is E19-33T. Single copies are 25 cents with special prices on quantity orders.

"HOW TO FIGURE Oxwelding and Cutting Costs." An 8-page pamphlet published by The Linde Air Products Co., New York, was prepared to be of particular value to managers and supervisors who wish to set up methods of figuring oxwelding and cutting costs best suited to their particular needs. Three different methods for computing material consumption, and the conditions under which each should be used, are presented in tabular form for ready reference.

TRIFLEX LININGS in steel pickling tanks are described and illustrated in a booklet from the B. F. Goodrich Rubber Co., Akron, Ohio. A layer of hard rubber is vulcanized between two layers of soft rubber and the whole bonded to the steel to form an acid-proof lining.

HYDRO-ASH equipment of the Hydro-Ash Corp., 115 So. Dearborn St., Chicago, Ill., is described in a 14-p. illustrated catalog recently received.

KOLD KAN refrigeration, as developed by Frick Co., Waynesboro, Pa., has stored in the cans sufficient refrigeration to maintain a low temperature during shipment and handling. The equipment and process are shown in Bulletin No. 402-A. issued by the Frick Co.

INGERSOLL-RAND CO., 11 Broadway, New York, has recently issued its catalog No. 3064 describing the new IR two-stage, air-cooled, gasoline engine driven, portable air compressors.

SULLIVAN MACHINERY CO., 400 No. Michigan Ave., Chicago, Ill., is issuing two new bulletins. No. 88-I describes its 8-in. stroke angle compressor in capacities 350 to 500 c.f.m. for pressures up to 125 lb. No. 88-D is on single-stage angle compressors for low-pressure service in 2 and 4-cylinder types.

HIGH-PRESSURE heat exchangers made by the Lummus Co., 50 Church St., New York City are shown in bulletin E-1 recently issued.

MASON-NEILAN compensated temperature control instruments, including the Thermo-Pressure compensator are shown in a 32-p. bulletin of Mason Regulator Co., 1190 Adams St., Boston, Mass.

LITTLE GIANT boilers for moderate steam users are described in a folder from Union Iron Works, Erie, Pa.

BURT VENTILATORS is the title of a folder recently issued by the Burt Mfg. Co., Akron, Ohio, showing construction and application of various types, also giving dimension tables. One page gives a condensed summary on Burt oil filters and exhaust heads.

IN ITS notes No. 19 the Commodore Heaters Corp., 11 W. 42nd St., New York City, tells about and gives tables of "certified performance" of its built-in connectofin heaters, as check by Frost Research Laboratory against ratings of A. S. H. & V. E.

ROTAX controller for temperature, pressure, humidity and liquid levels, with rotating electric contacts, as made by the Foxboro Co., Foxboro, Mass., is described in its bulletin 184, which shows construction, method of operation and industrial processes where application of this equipment is desirable.

NEW 6 BY 9-IN. four-cycle Transit engines are announced by National Transit Pump & Machine Co., Oil City, Pa., in bulletin 430. Sizes are 20 to 100 hp. in 2, 3, 4 and 6 cylinder arrangement. Speed is stated to be moderate and change readily made for operation on natural or refinery gas or as a solid-injection Diesel.

VIKING PUMPS for Fuel Oil Burners is the title of bulletin 702-33 of the Viking Pump Co., Cedar Falls, Iowa, giving types, details and dimension tables.

RIVERSIDE BERYLLIUM COPPER is the title of a booklet just issued by the Riverside Metal Co., Riverside, N. J., which gives pertinent facts about beryllium and the qualities beryllium imparts to copper alloys.

NATIONAL ALUMINATE CORP. of Chicago has just issued a catalog entitled A Scientific Boiler Water Treatment which describes a new system of treating boiler feedwater known as the Nalco AB system.

REPUBLIC STEEL CORP., Youngstown, O., has just issued a folder dealing with the properties of Toncan iron in a comprehensive manner. Its usage, fabrication, chemistry, physical constants, physical properties and methods of treatment are brought out in the folder.

THE MARLEY CO., Kansas City, Mo., has just issued its Bulletin No. 40 illustrating and describing in considerable detail the pertinent features of the Marley spray deck type cooling towers.

EAGLE 66 INSULATING cement for covering all surfaces from which heat can escape is described and its method of use detailed in a booklet issued by The Eagle-Picher Lead Co., Cincinnati, Ohio.

Power Plant Construction News

Ala., Muscle Shoals—Common Council, George McBride, mayor, plans construction of a municipal power substation and transmission line, about 20 miles long, to Wilson Dam, where power will be secured for local light and power service. Estimates of cost are being made. J. W. Johnson is engineer.

Ariz., Tucson—Southwestern Brewing Co., 402 Consolidated National Bank Building, recently organized, plans installation of electric and steam power equipment in proposed new brewing plant on Seventeenth Street. A boiler house will be built. Entire project will cost about $250,000. William E. Gleason is president.

Calif., Fresno—San Joaquin Light & Power Corporation, Fresno, is planning installation of new underground conduit system on Fresno Street, from H to O Street, to replace present overhead transmission lines. Estimated cost $75,000. Company engineering department is in charge.

Calif., San Diego—Aztec Brewing Co., recently organized, will install electric and steam power equipment, tanks, pumping machinery, refrigerating machinery and other equipment for new brewing plant on Main Street, where company has acquired former mill of Savage Tire Co., to be remodeled for project. Cost over $200,000. Richard Griesser, 64 West Randolph Street, Chicago, Ill., is architect and engineer.

Calif., Victorville—Victorville County Water District plans installation of deep-well pumping machinery with capacity of 100,000 gal. per day, elevated steel tank and tower (or reinforced concrete reservoir) with capacity of 150,000 gal., pipe lines, etc., in connection with new water supply system. A fund of $50,000 has been approved. Charles L. Foulke, 455 Fourth Street, San Bernardino, Calif., is consulting engineer.

Ill., North Chicago—City Council, Michael Opeka, clerk, is arranging financing in amount of $425,000, for a municipal electric light and power plant, and proposes to ask bids for equipment in near future. Neiler-Rich & Co., 431 South Dearborn Street, Chicago, consulting engineer, has recently completed surveys and estimates of cost.

Ky., Covington—Bavarian Brewing Co., Pike and Twelfth Streets, plans installation of electric power equipment, conveying and other equipment in connection with new two-story addition and improvements in present plant. Cost about $150,000. Leslie S. Deglow, 9 West Fourth Street, and Carl J. Kiefer, Schmidt Building, both Cincinnati, Ohio, are architect and consulting engineer, respectively.

Ky., Louisville—Louisville Water Co., Louisville, is planning installation of steam turbo-generator unit, condensers and other equipment at waterworks power plant. Bids will soon be asked. Cost reported over $50,000. Alvord, Burdick & Howson, 20 North Wacker Drive, Chicago, Ill., are consulting engineers.

La., Baton Rouge—Rock Ice Co., Baton Rouge, has taken out permit for construction of new one-story ice-manufacturing plant, 65 x 97 ft., reported to cost about $25,000, with equipment. Work will be placed under way at early date.

Mass., Boston—Croft Brewing Co., operating former Highland Spring Brewery, Terrace and Parker Streets, Roxbury Crossing, plans installation of electric and steam power equipment for expansion and improvements at plant. Cost over $200,000. Walter J. Croft is vice-president and production manager. John F. Hunt & Co., 545 West Twentieth Street, New York, N. Y., are architects and engineers.

Mich., Battle Creek—Battle Creek Ice & Cold Storage Co., plans installation of electric power equipment, refrigerating and other machinery in proposed new brewing plant. Company will remodel and equip existing building for plant. Cost about $80,000.

Mich., Ludington—Department of Public Works has preliminary plans under way for a municipal electric light and power plant, estimated to cost about $338,000, with prime movers and auxiliary equipment.

Mich., Owosso—Michigan Sugar Co., Saginaw, Mich., plans installation of motors and other power equipment in connection with improvement and modernization program at beet sugar mill at Owosso, idle for about five years past. Cost about $70,000.

Minn., Mora—Village Council, H. F. Robinson, clerk, will soon take bids on revised plans for municipal electric power plant and distributing system. Cost about $65,000. Bids recently received for equipment, including Diesel engine units, have been rejected. G. M. Orr & Co., Baker Building, Minneapolis, Minn., are consulting engineers.

Minn, St. Cloud—St. Cloud Brewing Co., care of John P. J. Dolan, 1508 Pioneer Building, St. Paul, Minn., recently formed by Mr. Dolan and associates, plans installation of electric and steam power equipment, bottling machinery, conveyors and other equipment for expansion and improvements at local brewing plant. Cost about $55,000.

N. J., Orange—J. F. Trommer, Inc., 1632 Bushwick Avenue, Brooklyn, N. Y., plans installation of electric and steam power equipment, tanks, conveyors, pumps and other machinery for an expansion and modernization program at Orange Brewery, recently acquired, to be developed as a branch plant. Power house will be converted for use of fuel oil instead of coal, as heretofore. Entire project will cost close to $400,000.

N. J., Trenton—J. J. Murphy Brewing Co., care of John J. Murphy, Edinburg Road, recently formed with capital of $500,000, plans installation of electric and steam power equipment, mechanical-cooling and complete brewing machinery in new three-story plant at North Clinton and Perrine Avenues. It will cost over $300,000. A boiler house is planned. Waldemar Mortensen, 103 Park Avenue, New York, N. Y., is engineer.

N. C., Kinston—Hines Brothers Lumber Co., plans installation of electric power equipment in connection with rebuilding of lumber and planing mill, recently damaged by fire. New boiler house is proposed. Cost over $75,000.

Ohio, Canton—Tuscora Brewing Co., recently organized by Edward Rommel and associates, to take over former local Stark-Tuscarawas Breweries Co., plans installation of electric power equipment, refrigerating machinery, conveyors and other equipment for expansion and modernization of brewing plant. Cost close to $200,000.

Ohio, Oberlin—L. A. Sears, city manager, City Hall, is planning early call for bids for extensions and improvements in municipal electric light and power plant, including installation of Diesel engine-generator units. Also for electric distribution system. Cost about $250,000. R. Husselman, Hippodrome Building, Cleveland, Ohio, is consulting engineer.

Ohio, Williamsburg—Department of Public Affairs, Harvey McKeever, president, has plans for a municipal electric light and power plant to cost about $90,000, and proposes early construction. H. G. Bryan, Park Avenue, Loveland, Ohio, is consulting engineer.

Ore., Portland—Blitz-Weinhard Co., 627 Upshur Street, plans installation of electric and steam power equipment in new two-story brewing plant, with capacity of about 50,000 barrels per year. Cost over $100,000.

Pa., Columbia—Columbia Brewing Co., Philip Knoblauch, head, plans installation of motors and other electric power equipment, conveyors, bottling machinery, etc., for expansion and improvements at brewing plant. Estimated cost about $50,000.

Pa., Williamsport—Flock Brewing Co., plans installation of electric power equipment in connection with expansion and modernization program at brewing plant, to increase capacity to about 100,000 barrels a year. Program will cost over $75,000.

S. C., Charleston—New Ice Co., Charleston, has approved plans for construction of one-story ice-manufacturing plant. Cost about $25,000 with equipment. Work will soon begin.

Texas, Plainview—City Council has been authorized, by vote of citizens, to arrange bond issue of $450,000, for a municipal electric light and power plant. Proposed to begin work at early date.

Texas, Teague—Sinclair-Prairie Pipe Line Co., Tulsa, Okla., affiliated with Sinclair Oil Co., 45 Nassau Street, New York, N. Y., plans installation of series of pumping plants and booster stations for operation of proposed new crude oil pipe line from point near Teague to Huffman Station, near Houston, Tex., about 150 miles. Entire project will cost over $600,000. Company engineering department is in charge.

Va., Norfolk—Allied Mills, Inc., 141 West Jackson Boulevard, Chicago, Ill., plans installation of electric power equipment in new soy bean processing plant at Southgate Industrial Terminal, Norfolk, where 3-acre tract of land has been acquired. A boiler house will be built. Entire project will cost over $300,000.

Va., Richmond—Virginia Airship Co., Inc., Garrett W. Peck, 23 South Boulevard, general manager, plans installation of motors and other electric power equipment at new aircraft manufacturing plant on local site. Work will include two main units, 200x750 ft., and 97x100 ft. A power house will be built. Entire project will cost about $250,000.